Above

GEOPHYSICAL SURVEY
GROUND WATER EVALUATION
KOHALA RANCH
ISLAND OF HAWAII

GEOPHYSICAL SURVEY
GROUND WATER EVALUATION
KOHALA RANCH, ISLAND OF HAWAII

Prepared For:

Kohala Joint Venture
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May 18, 1990

(Our Project #90016)

Table of Contents

EXECUTIVE SUMMARY

A surface geophysical survey was conducted at the Kohala Ranch Development between March 26 and April 25, 1990 for the purpose of assisting in mapping ground water resources.

Ground water resources in geologic settings, such as that found on the Kohala Ranch Development, are of two types:

(1) Basal fresh water where a lens of fresh water floats on sea water, and the elevation of the interface can be described by the Ghyben-Herzberg equation. This equation states that for every foot of fresh water head above mean sea level, 40 ft of fresh water is expected below sea level.

(2) Dike-confined water where geological structures such as intrusive rock bodies and dikes control the ground water regime. Fresh water heads in these areas are controlled by many factors, and can be highly variable.

INAPPROPRIATE ASSUMPTION

At the Kohala Ranch both types of water resources occur and the geophysical surveys outlined boundaries between these types of hydrological provinces. In areas of basal fresh water occurrences the thickness of lenses of fresh water were computed. In areas of dike-confined water, areas of similarity in geophysical responses and expected hydrology were outlined.

1.0 INTRODUCTION

This report contains the results of a geophysical survey for ground water resource evaluation at the Kohala Ranch Development (KRD) on the Island of Hawaii. The work was performed by Blackhawk Geosciences, Inc. (BGI) for Kohala Joint Venture during March 26 to April 26, 1990.

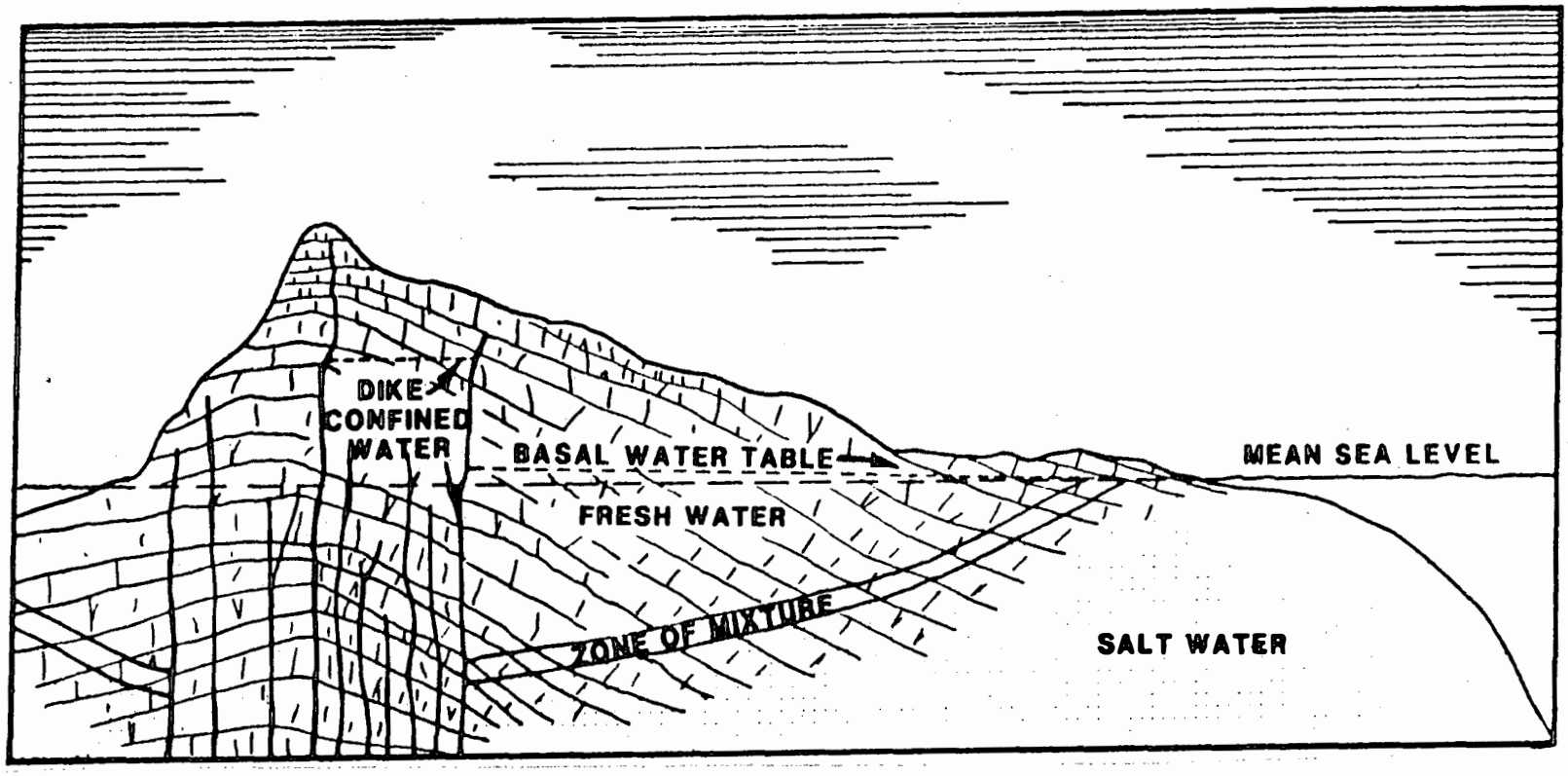
The general objective of the geophysical survey at KRD was to assist in characterizing the hydrologic regime in the study area. Recent drilling results revealed abnormally high static water levels in a well on the property, and the geophysical survey was performed to attempt to map the extent and cause of this anomaly. The generalized objectives for geophysical surveys for ground water evaluations on volcanic islands are illustrated in Figure 1-1. The volcanic rocks are generally highly permeable and this allows rainwater to percolate with little impedance directly downward through the island mass. The fresh water in these island settings is generally found in two environments:

1. Dike-confined waters. Typically, above the rift zone, intrusive dikes originating from a magma source below can form ground water dams, and behind these natural dams significant quantities of ground water can be stored.

2. Basal fresh water. The high permeability of the volcanic rocks allows sea water to enter freely under the island, and a delicate balance is reached where a lens of fresh water floats on sea water. In cases of hydrostatic equilibrium, the Ghyben-Herzberg relation states that for every foot of fresh water head above sea level there will be 40 ft of fresh water below sea level.

At KRD both dike-confined and basal fresh water resources were indicated due to the large variation in static water levels at the various wells within the development (well #3 ≈ 150 ft, wells #1 and #2 ≈ 6 ft). The impetus for using geophysics is that the cost of a geophysical station is about one-thousandth the cost of completing a well at elevations above 1,000 ft. Geophysical surveys, combined with other hydrogeologic information, are used to provide optimum locations for well placement and well completion depths.

The geophysical method employed was time domain electromagnetic (TDEM) soundings. This method was selected because it has proven effective in prior surveys in similar settings in Hawaii.



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SCHEMATIC HYDRO-GEOLOGIC CROSS SECTION
KOHALA RANCH PROJECT
NORTH KOHALA, HAWAII

PROJECT NO.: 90016 FIGURE 1-1

2.0 LOGISTICS AND DATA ACQUISITION

A brief description of the fundamentals of TDEM are given in Appendix A. Briefly, the logistics of a TDEM measurement consist of:

1. Laying out a square loop of insulated wire. A generator placed in the loop is used to drive current pulses through this closed loop. The dimensions of the square loops employed depend on the exploration depth requirements. The dimensions of the loops used for KRD were 1,000 ft by 1,000 ft on each side for all loops, with the exception of loop 1W where a 500 ft by 500 ft transmitter loop was used.

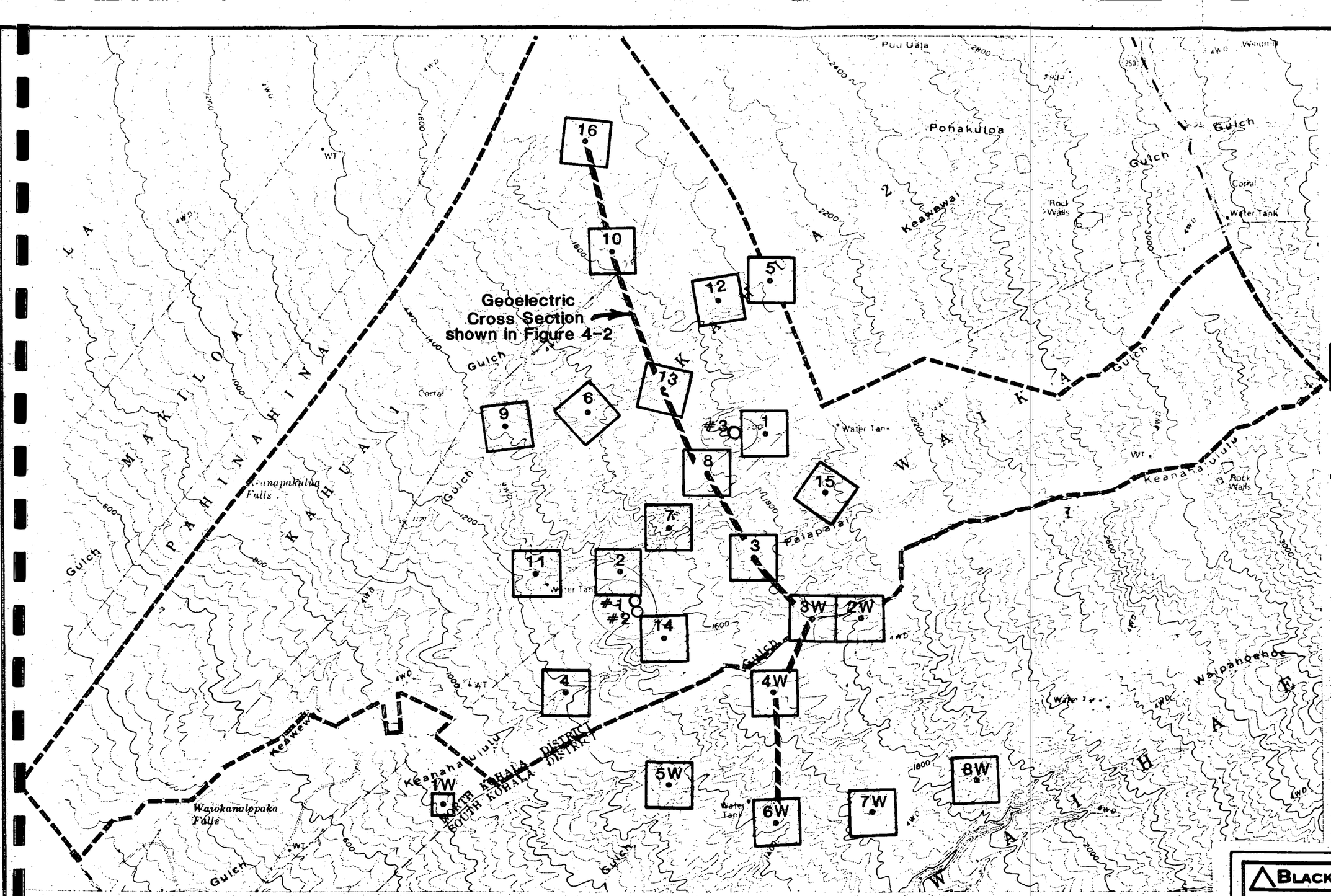
   Transmitter loop wires were positioned so as not to cross utility lines. Soundings 1, 2 and 1W were positioned near wells.

2. Making a measurement with a receiver in the center of the loop. The data acquired at each station was stored in the field on a solid state data logger and subsequently dumped to a computer at the end of each field day. The data acquired at each station usually consisted of measurements at several receiver gain settings and transmitter frequencies in order to assure data quality and to obtain data over the largest time range possible. Data quality was generally very good.

During the 8 days of field work 24 stations (soundings) were completed. A daily log of field activity is given in Table 2-1. Figure 2-1 shows the location of the soundings conducted for KRD.

Table 2-1. Daily log of field activities

Date (1990)	Activity
March 26	BGI personnel mobilize from Golden, CO to Kailua-Kona, Hawaii in conjunction with the other surveys.
April 5	Meet with KRD personnel and check survey areas.
April 6	Soundings 1, 2 and 3.
April 7	Soundings 4, 5 and 6.
April 8	Soundings 7, 8, 9 and 10.
April 9	Soundings 11, 12 and 13.
April 10	Soundings 14, 15 and 16.
April 11-12	Demobilize to Golden, CO and perform preliminary analysis of data.
April 18	Mobilize to Kailua-Kona, Hawaii.
April 23	Soundings 1W, 2W and 3W.
April 24	Soundings 4W, 5W and 6W.
April 25	Soundings 7W and 8W.
April 26	Demobilize to other Hawaii geophysical surveys.



LEGEND

- 1 — Sounding Loop Location
- #3 — Well Number and Location
- Approximate Ranch Boundary

1000 0 1000 2000 3000

SCALE - FEET

BLACKHAWK GEOSCIENCES, INC.

TDEM SURVEY LOCATION MAP

KOHALA RANCH PROJECT
NORTH KOHALA, HAWAII

PROJECT NO.: 90016 **FIGURE 2-1**

3.0 DATA PROCESSING

The field data acquired each day was transferred from the DAS-54 data logger to a Compaq computer. The data for each sounding location is edited and combined (both 3 Hz and 30 Hz frequencies) to produce a transient decay curve. This decay curve is transformed into an apparent resistivity curve, which is entered into an Automatic Ridge Regression Transient Inversion Program (ARRTI). From the apparent resistivity curve a one-dimensional model of resistivities and thicknesses is calculated.

The inversion program requires an initial estimate of the geoelectric section, including the number of layers, and the resistivities and thicknesses of each of the layers. The program then adjusts these parameters so that the model curve converges to best fit the curve formed by the field data set. The inversion program does not change the total number of layers within the model, but allows all other parameters to float freely.

An example data set is given in Figures 3-1 and 3-2 for sounding KR1. Figure 3-1 shows the measured data points (in terms of apparent resistivity) superimposed on a solid line. The solid line represents the computed behavior of the true resistivity layering shown on the right. Figure 3-2 lists in column 4 the error between measured and computed data in each time gate.

The apparent resistivity curves and data sheets for all soundings are contained in Attachment A.

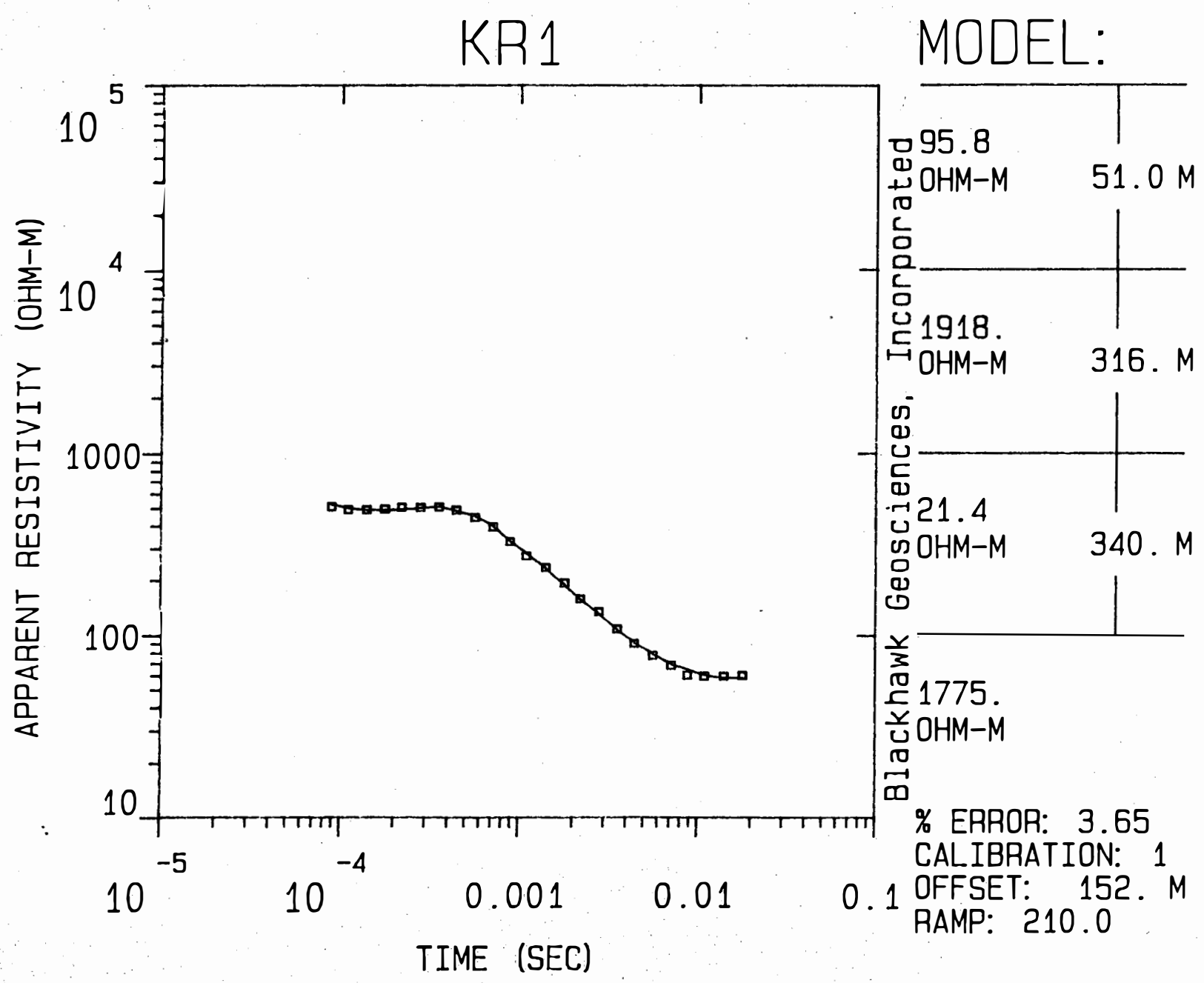

KR1
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
MODEL:
95.8
OHM-M
51.0 M
1918.
OHM-M
316. M
21.4
OHM-M
340. M
1775.
OHM-M
% ERROR: 3.65
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0
Blackhawk Geosciences, Incorporated

FIGURE 3-1

FIGURE 3-2

KR1

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		579.1	1900.0		
95.78	51.0	528.1	1732.6	0.5	0.5
1918.02	316.3	211.8	694.8	0.2	0.7
21.40	339.5	-127.7	-419.1	15.9	16.6
1774.88					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	5.09E+02	5.26E+02	-3.141	
2	1.10E-04	4.90E+02	4.99E+02	-1.693	
3	1.40E-04	4.91E+02	4.86E+02	1.058	
4	1.77E-04	4.96E+02	4.88E+02	1.606	
5	2.20E-04	5.06E+02	4.94E+02	2.547	
6	2.80E-04	5.05E+02	5.04E+02	0.196	
7	3.55E-04	5.07E+02	5.13E+02	-1.261	
8	4.43E-04	4.88E+02	4.80E+02	1.563	
9	5.64E-04	4.45E+02	4.52E+02	-1.521	
10	7.13E-04	3.95E+02	3.99E+02	-1.130	
11	8.90E-04	3.27E+02	3.29E+02	-0.409	
12	1.10E-03	2.73E+02	2.81E+02	-2.843	
13	1.41E-03	2.35E+02	2.32E+02	1.523	
14	1.80E-03	1.94E+02	1.87E+02	3.585	
15	2.20E-03	1.59E+02	1.56E+02	1.501	
16	2.80E-03	1.34E+02	1.30E+02	3.090	
17	3.55E-03	1.08E+02	1.07E+02	1.757	
18	4.43E-03	9.06E+01	9.13E+01	-0.692	
19	5.64E-03	7.79E+01	7.90E+01	-1.382	
20	7.13E-03	6.86E+01	6.96E+01	-1.438	
21	8.81E-03	6.07E+01	6.49E+01	-6.573	
22	1.10E-02	6.00E+01	6.06E+01	-0.967	
23	1.41E-02	5.99E+01	5.83E+01	2.780	
24	1.80E-02	6.03E+01	5.85E+01	3.120	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 24 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR1
0604 0001 0001 Z OPR XTL H 4 10+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 1.56E-02, ANTILOG YIELDS 3.6503 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.94
P 2 -0.03 0.05
P 3 0.01 -0.02 0.97

4.0 INTERPRETATION RESULTS

4.1 GENERAL

The main objective of the geophysical survey is not to obtain the resistivity layering of the subsurface, but to infer from the resistivity layering information about the elevation and thickness of the fresh water resource. The translation of resistivity layering into meaningful hydrogeologic information is generally accomplished in two ways:

1. Using available knowledge about the relation between resistivity values and hydrogeology. For example, in the volcanic rocks of Hawaii, rocks saturated with salt water will generally have resistivities less than 5 ohm-m. On the other hand, dry and fresh water/brackish water saturated volcanic rocks and intrusives can have very high resistivities (greater than 1,000 ohm-m).

2. Calibrating the geophysical interpretation at a well. In this case several wells were available for comparison. The approximate location of these wells are shown in Figure 2-1. The two wells (#1 and 2) located at lower elevation (1,460 ft) had static water levels (heads) of 6 ft above sea level. The well #3 located at higher elevation (1,835 ft) had a head of approximately 150 ft above sea level. This large difference in heads over the approximate 4,000 ft distance can best be explained by major geologic structures (rifts, dikes, etc.) which act to dam ground water flow.

In the case where a very conductive layer is detected below sea level in the TDEM interpretation, then the layer is expected to be caused by saline saturated volcanics. Static water levels (heads) can be calculated from these soundings by using the Ghyben-Herzberg relation. This relation, however, assumes hydrostatic equilibrium and is not expected to apply to soundings in close proximity to ground water damming structures.

The soundings acquired in a large area around wells #1, 2 and 3 did not detect salt water saturated volcanics below sea level. The behavior of the ground water in these areas is, therefore, expected to be dike or structure controlled. Other TDEM soundings in the survey area were able to detect salt water saturated volcanics below sea level, and for these soundings ground water levels may behave according to the Ghyben-Herzberg relationship.

4.2 GEOELECTRIC CROSS-SECTION

The results of some the TDEM interpretations are presented as a south to north geoelectric cross section in Figure 4-1. In the geoelectric section layers with similar resistivities have been linked together. In the geoelectric section soundings 6W and 4W (on the south) and soundings 10 and 16 (to the north) show similar three-layer sequences. The upper surface layer (44 to 220 ohm-m) is interpreted to represent soils or weathered volcanics. The intermediate layer of very high resistivities (> 5000 ohm-m) is interpreted as unweathered volcanics. The portions of this layer below sea level are expected to contain fresh or brackish water. The deepest layer in the section with resistivities of 4.2 to 9.6 ohm-m is interpreted to represent salt water saturated volcanics.

In the geoelectric section beneath soundings 3W, 3, 8 and 13 a more complex layering sequence is interpreted. A third layer which exhibits resistivities from 2 to 22 ohm-m is interpreted as volcanic ash flows or altered volcanic occurring above and below sea level. The lowest layer beneath soundings 3, 8 and 13, with resistivities of 1030 to 1672 ohm-m, probably represents unaltered volcanics or intrusives to the maximum search depth (≈ 3,000 ft). Generally, it is difficult to discriminate between unaltered volcanics which are dry or which contain fresh or brackish water (less than 250 ppm chloride). The reason is that, in addition to salinity, changes in porosity and lithology also influence formation resistivity.

Within the geoelectric section several vertical structures are interpreted. These structures are likely caused by vertical dikes of impermeable rocks resulting in a barrier to ground water flow which may explain the high level ground water head (150 ft) at well #3.

4.3 INTERPRETATION MAP

In order to incorporate all the soundings into one data set, an interpretation map of the TDEM results for the Kohala Ranch area was constructed (Fig. 4-2). In this figure the soundings which detected saline saturated volcanics below sea level are separated from the soundings which have a resistive basement (or conductive basement which occurs above sea level). In other words, soundings which are expected to represent basal saline water are separated from soundings which are influenced by dike impoundment or other geologic structures.

In this figure the elevation of the top of the salt water interface derived from the TDEM measurements is contoured. These values will be approximately equal to the thickness of the fresh-brackish water lens if the basal water is in equilibrium. In addition to the TDEM data, static water level (heads) from three

wells drilled on the ranch property are shown on the contour map (information furnished by Nance, 1990, personal communication).

The main features evident in the interpretation map are:

(1) Areas outside the boundary between impounded and basal water generally show the salt water interface to deepen towards the northeast. On the south side of the boundary the depth to basal saline water increases rapidly with increasing elevation. On the north side of the boundary the depth to saline water increases gradually with increasing elevation.

(2) The area interpreted to be effected by confining structures extends in a narrow zone from about 1,000 ft above sea level near sounding 4 and widens with increasing elevation towards the northeast. Wells #1 and #2 also lie within the interpreted dike confined water zone.

Within the boundary the TDEM data can be grouped according to comparable model results. Soundings 2, 4, 11 and 14 (near wells #1 and #2) have similar two-layer model results. These soundings show a thick resistive (280 to 497 ohm-m) layer above a conductive layer (3 to 5 ohm-m) both occurring above sea level. This lower conductive layer is most likely interpreted as volcanic ash flows or altered volcanics.

Soundings 1, 8 and 13 in the vicinity of well #3 have comparable model results. Each sounding shows a four-layer sequence (Fig. 4-1) with the deep resistive layer (1049 to 1775 ohm-m) interpreted as unaltered volcanics or intrusives. Sounding 7, which does not fit in either of these two grouped areas exhibits a three-layer sequence with a lower resistive (181 ohm-m) layer occurring approximately 748 ft below sea level. This lower layer may also be best interpreted as unaltered volcanics or intrusives.

Soundings 3 and 15 have similar four-layer model results with a resistive lower layer (1030 to 1688 ohm-m) occurring above sea level. This layer is most likely interpreted as unaltered volcanics or intrusives.

Models for soundings 2W and 3W are similar to each other, but are quite different from surrounding soundings (Fig. 4-1). These soundings are located close to the interpreted boundary between basal and dike-confined water. This closeness to the boundary may be the reason for differences seen between these sounding sets.

Soundings 5 and 12 have similar three layer model results. Both soundings show a resistive (79 to 360 ohm-m) layer at depth

occurring below sea level. This lower layer can best be interpreted as unaltered volcanics or intrusives.

4.4 HYDROGEOLOGIC INTERPRETATION

The geophysical interpretation (Fig. 4-2) outlined two areas of different hydrogeologic parameters, i.e., an area in which the ground water is expected to be controlled by geologic structures (dikes, intrusives, etc.) and an area in which the ground water is expected to occur mainly in the basal mode. Within the area interpreted to be controlled by geologic structures, the hydrologic parameters such as static head and volume of the ground water resource, cannot be inferred from the geophysical data. This is due to the fact that the presence or absence of fresh water has little effect upon the electrical resistivity measured by the TDEM method. In areas with comparable TDEM results (see Section 4.3) it can be assumed that similar hydrologic parameters may exist. For example, soundings 1, 8 and 13 near well #3 all display similar results, and therefore likely outline the extent of the structure which creates the anomalous head at well #3. Similarly, the soundings around wells #1 and #2 (11, 2, 14, and 4) all display similar results and could be expected to define the boundary of the lower heads seen in these wells. Geologic structures are inferred between separate groups of soundings with similar results (reference Figs. 4-1 and 4-2).

In the area interpreted to be represented by basal water resources, the fresh water resource can be estimated by the volume between sea level and the elevation of the interpreted saline water. If this water can be assumed to be hydrostatic equilibrium, then the static water level (head) can be calculated using the Ghyben-Herzberg relation. Table 4-1 shows the thickness of the fresh/brackish water lens obtained directly from the model results for each sounding.

Table 4-1. Hydrogeologic information derived from TDEM soundings

Sounding #	Surface Elevation (ft)	Approximate Thickness of Fresh/Brackish Water Lens (ft)
6	1550	272
9	1420	204
10	1850	419
16	1890	295
1W	830	98
4W	1665	771
5W	1340	484
6W	1450	778
7W	1680	905
8W	1885	1000?

SOUTH

NORTH

Bend in Section

WELL #3

6W 4W 3W 3 8 13 10 16 SOUNDING NUMBER

SURFACE

ELEVATION (feet)

2000

1000

0

-1000

-2000

SEA LEVEL

44 198 161 137 70 195 220

71

543 668

1104 1967

4680 >5000

>5000 >5000

17 2 22

12 1030 1672 1049

9.6 7.6

8.2

4.2

AT ABOUT 1800 ' ELEV

4.2 Values in Ohm-m

HORIZONTAL EXAGERATION 2 TO 1

1000 0 1000 2000 3000 4000

SCALE - FEET

LEGEND

- Soils or Weathered Volcanics
- Unweathered Volcanics
- Volcanic Ash Flows or Altered Volcanics
- Unaltered Volcanics or Intrusives
- Salt Water Saturated Volcanics
- Inferred Geologic Structure

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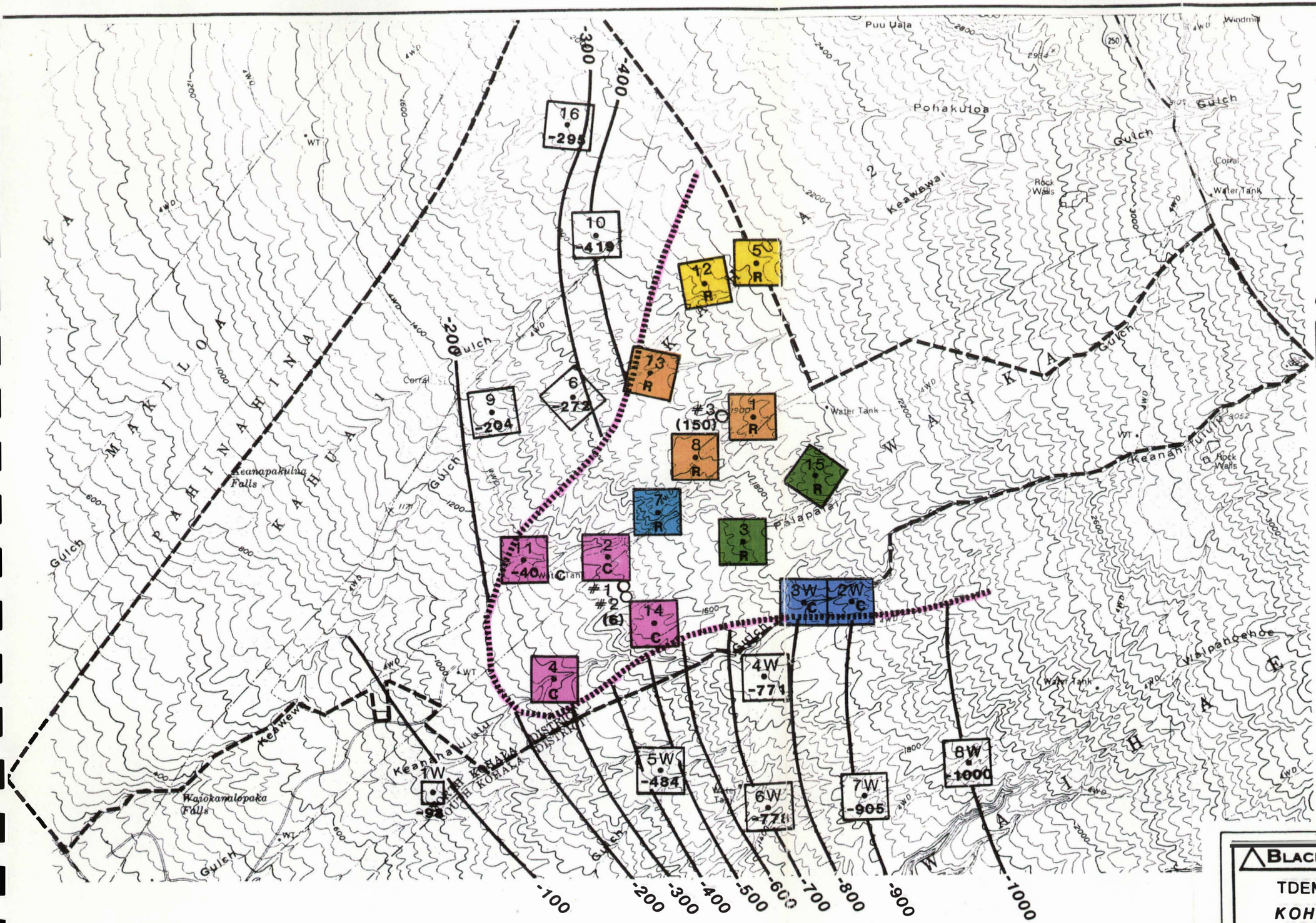
TDEM SURVEY
GEOLOGIC CROSS SECTION
KOHALA RANCH PROJECT
NORTH KOHALA, HAWAII

PROJECT NO.: 90016 FIGURE 4-1



LEGEND

- Interpreted Boundary between Basal and Dike confined Water
- -295 — Approximate location of top of interpreted Salt Water Interface (feet)
- C — Conductive Basement
- R — Resistive Basement
- (140) — Static Water Level at Well (feet)
- 1 — Sounding Loop Location
- #3 — Well Number and Location
- Approximate Ranch Boundary

1000 0 1000 2000 3000

SCALE - FEET

BLACKHAWK GEOSCIENCES, INC.

TDEM INTERPRETATION MAP

KOHALA RANCH PROJECT
NORTH KOHALA, HAWAII

PROJECT NO.: 90016 FIGURE 4-2

5.0 CONCLUSIONS AND RECOMMENDATIONS

The results of the TDEM survey at KRD are summarized in Figure 4-2. In this figure areas of the development in which ground water is expected to be controlled by geologic structures (dikes, intrusives, etc.) are separated from the area in which the ground water is expected to exist in the basal mode. The ground water resources within the area controlled by geologic structures cannot be determined directly from the TDEM data, however, sub-zones in which the hydrologic parameters are expected to be the same have been identified. For example, soundings 1, 8 and 13 near well #3 all exhibit similar behavior, and therefore can be expected to define the limits of the structure in which well #3 was positioned. Structures are inferred to exist between groups of soundings with similar results.

In the area interpreted to be represented by basal water resources, the fresh water resource is expected to be the volume between sea level and the elevation of the interpreted salt water. If the area can be assumed to be in hydrostatic equilibrium then the static water level (head) can be calculated using the Ghyben-Herzberg relation. The applicability of the Ghyben-Herzberg relationship in the area is expected to be marginal due to the existence of ground water damming structures.

ATTACHMENT A

GEOPHYSICAL SURVEY
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ISLAND OF HAWAII

ATTACHMENT A

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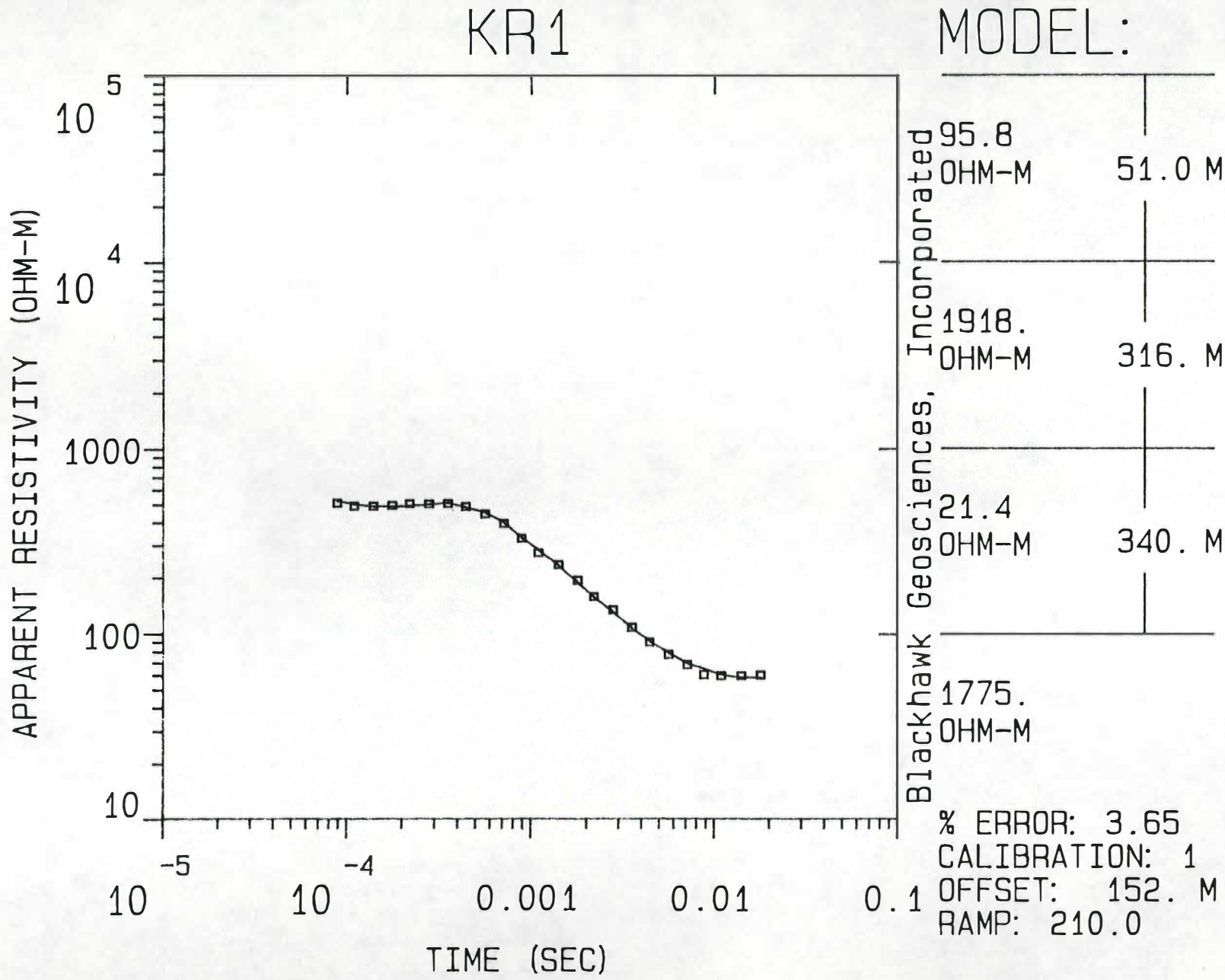

MODEL:

95.8 OHM-M — 51.0 M

1918. OHM-M — 316. M

21.4 OHM-M — 340. M

1775. OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 3.65
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR1

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		579.1	1900.0		
95.78	51.0	528.1	1732.6	0.5	0.5
1918.02	316.3	211.8	694.8	0.2	0.7
21.40	339.5	-127.7	-419.1	15.9	16.6
1774.88					

	TIMES	DATA	CALC	% ERROR	STD ERR
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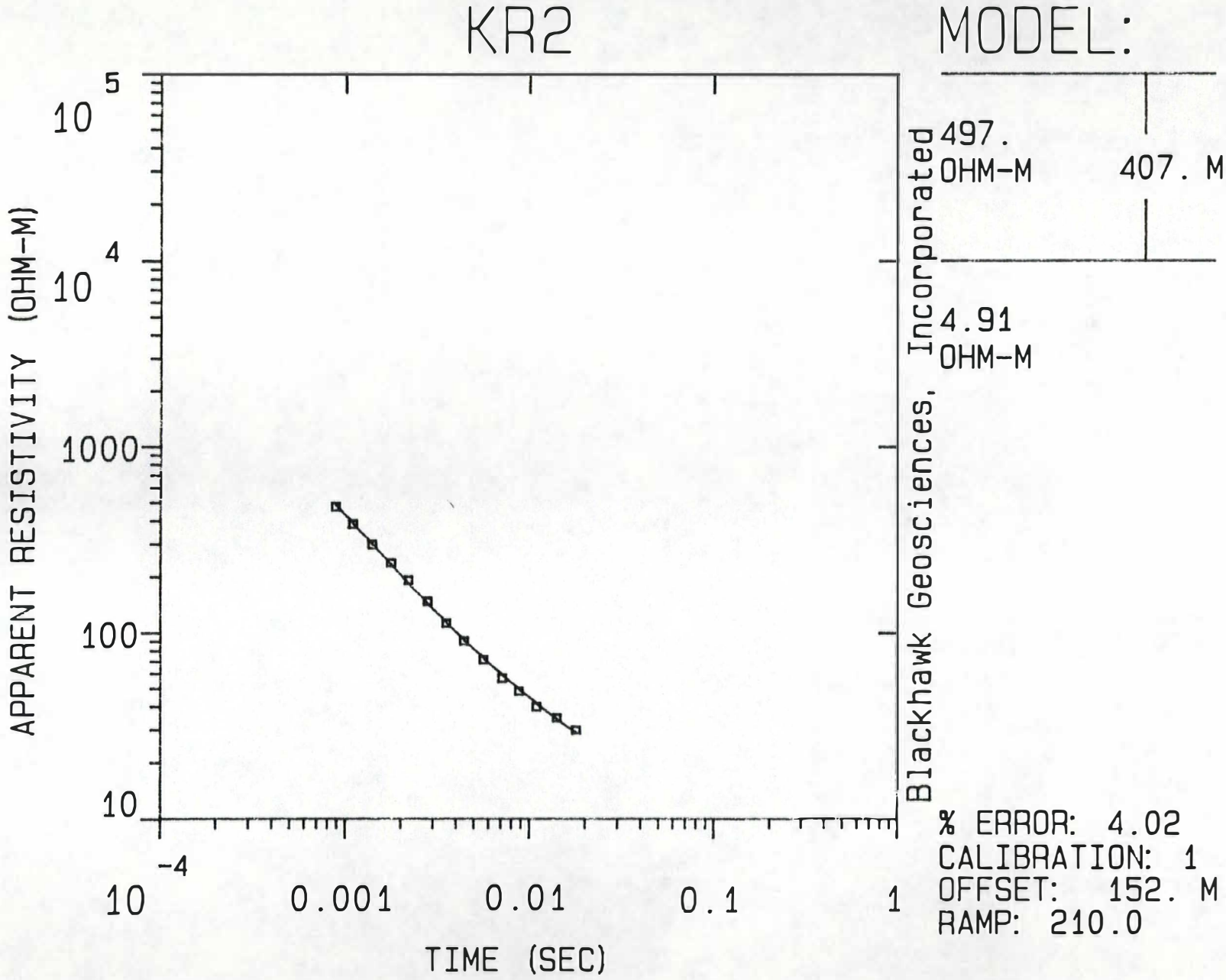
8	4.43E-04	4.88E+02	4.80E+02	1.563	
9	5.64E-04	4.45E+02	4.52E+02	-1.521	
10	7.13E-04	3.95E+02	3.99E+02	-1.130	
11	8.90E-04	3.27E+02	3.29E+02	-0.409	
12	1.10E-03	2.73E+02	2.81E+02	-2.843	
13	1.41E-03	2.35E+02	2.32E+02	1.523	
14	1.80E-03	1.94E+02	1.87E+02	3.585	
15	2.20E-03	1.59E+02	1.56E+02	1.501	
16	2.80E-03	1.34E+02	1.30E+02	3.090	
17	3.55E-03	1.08E+02	1.07E+02	1.757	
18	4.43E-03	9.06E+01	9.13E+01	-0.692	
19	5.64E-03	7.79E+01	7.90E+01	-1.382	
20	7.13E-03	6.86E+01	6.96E+01	-1.438	
21	8.81E-03	6.07E+01	6.49E+01	-6.573	
22	1.10E-02	6.00E+01	6.06E+01	-0.967	
23	1.41E-02	5.99E+01	5.83E+01	2.780	
24	1.80E-02	6.03E+01	5.85E+01	3.120	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 24 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR1
0604 0001 0001 Z OPR XTL H 4 10+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 1.56E-02, ANTILOG YIELDS 3.6503 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.94
P 2 -0.03 0.05
P 3 0.01 -0.02 0.97

P 4	0.00	0.00	0.00	0.00			
T 1	-0.08	-0.12	0.01	0.00	0.89		
T 2	0.01	0.04	0.00	0.00	0.01	1.00	
T 3	0.02	-0.03	-0.04	-0.01	0.02	0.01	0.92
	P 1	P 2	P 3	P 4	T 1	T 2	T 3


KR2
MODEL:
497.
OHM-M
407. M
4.91
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-4
0.001
0.01
0.1
1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 4.02
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR2

MODEL: 2 LAYERS

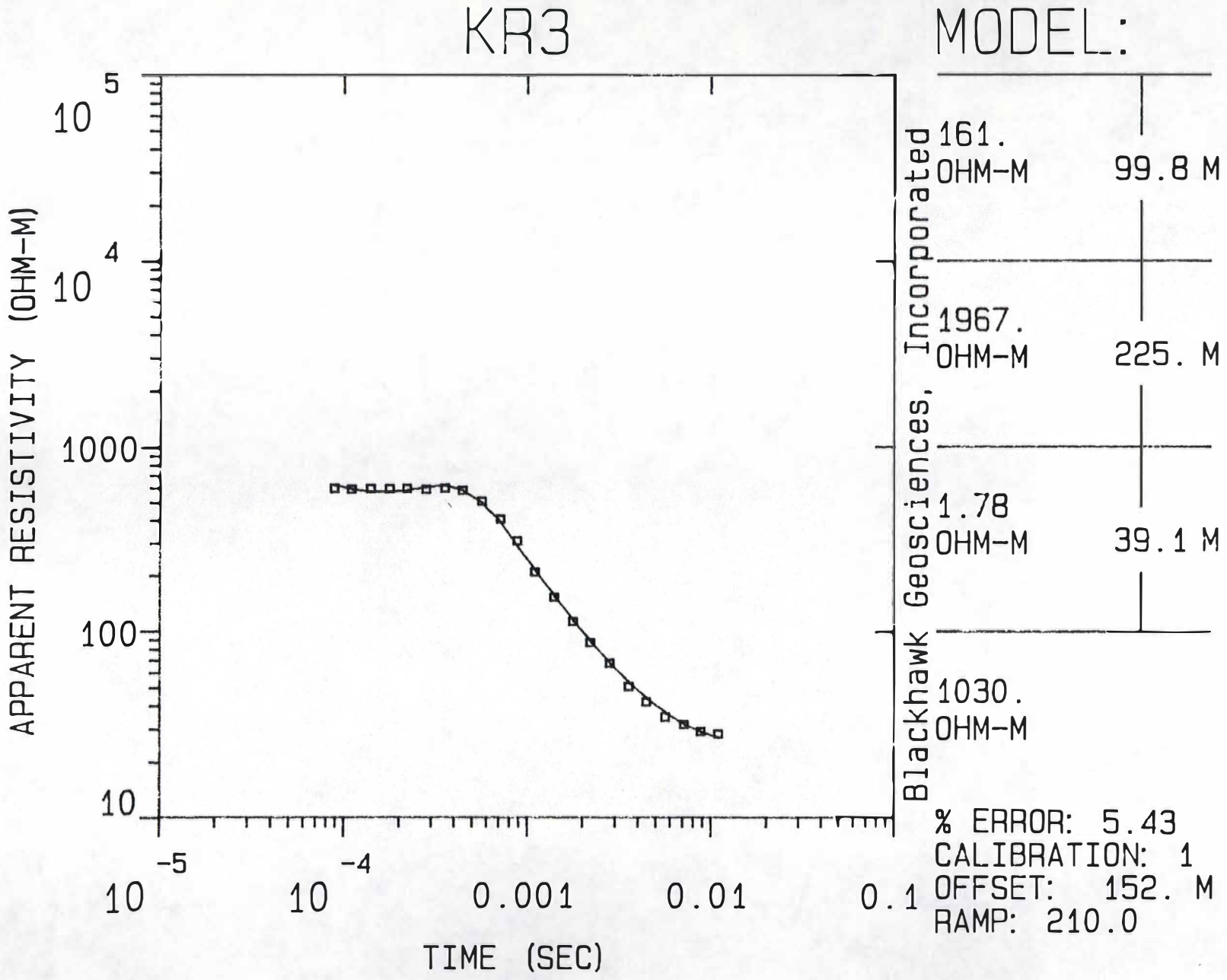
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		438.9	1440.0		
497.34	406.7	32.3	105.8	0.8	0.8
4.91					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-04	4.75E+02	4.87E+02	-2.475	
2	1.10E-03	3.63E+02	3.86E+02	-0.748	
3	1.40E-03	2.98E+02	2.99E+02	-0.160	
4	1.77E-03	2.38E+02	2.32E+02	2.548	
5	2.20E-03	1.92E+02	1.84E+02	4.562	
6	2.80E-03	1.48E+02	1.44E+02	2.935	
7	3.55E-03	1.13E+02	1.13E+02	-0.155	
8	4.43E-03	9.06E+01	9.13E+01	-0.694	
9	5.64E-03	7.15E+01	7.31E+01	-2.136	
10	7.13E-03	5.69E+01	5.91E+01	-3.687	
11	8.81E-03	4.85E+01	4.95E+01	-2.015	
12	1.10E-02	3.99E+01	4.14E+01	-3.544	
13	1.41E-02	3.48E+01	3.40E+01	2.274	
14	1.80E-02	2.98E+01	2.87E+01	3.742	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 14 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR2
0604 0002 0002 Z OPR XTL L 7 10+100
Ch.21 = 0.21 Ch.22 = 0.89 Ch.23 = 19.5 Ch.24 =
RMS LOG ERROR: 1.71E-02, ANTILOG YIELDS 4.0160 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.23
P 2 -0.10 0.93
T 1 0.02 0.00 1.00
P 1 P 2 T 1



MODEL:

161. OHM-M	99.8 M
1967. OHM-M	225. M
1.78 OHM-M	39.1 M
1030. OHM-M	

% ERROR: 5.43
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		536.4	1760.0		
161.23	99.8	436.6	1432.6	0.6	0.6
1966.89	224.9	211.8	694.8	0.1	0.7
1.78	39.1	172.7	566.6	22.0	22.7
1029.87					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	5.95E+02	6.23E+02	-4.598	
2	1.10E-04	5.89E+02	5.87E+02	0.317	
3	1.40E-04	5.93E+02	5.68E+02	4.356	
4	1.77E-04	5.91E+02	5.70E+02	3.811	
5	2.20E-04	5.94E+02	5.83E+02	1.961	
6	2.80E-04	5.87E+02	6.07E+02	-3.428	
7	3.55E-04	5.97E+02	6.22E+02	-4.078	
8	4.43E-04	5.79E+02	5.79E+02	0.023	
9	5.64E-04	5.07E+02	4.95E+02	2.339	
10	7.13E-04	4.07E+02	3.90E+02	4.421	
11	8.81E-04	3.10E+02	2.88E+02	7.532	
12	1.10E-03	2.10E+02	2.14E+02	-1.987	
13	1.40E-03	1.53E+02	1.56E+02	-1.680	
14	1.77E-03	1.13E+02	1.15E+02	-1.612	
15	2.20E-03	8.73E+01	8.84E+01	-1.213	
16	2.80E-03	6.76E+01	6.78E+01	-0.298	
17	3.55E-03	5.09E+01	5.34E+01	-4.660	
18	4.43E-03	4.20E+01	4.40E+01	-4.633	
19	5.64E-03	3.49E+01	3.68E+01	-5.138	
20	7.13E-03	3.19E+01	3.18E+01	0.269	
21	8.81E-03	2.92E+01	2.91E+01	0.499	
22	1.10E-02	2.84E+01	2.70E+01	5.094	

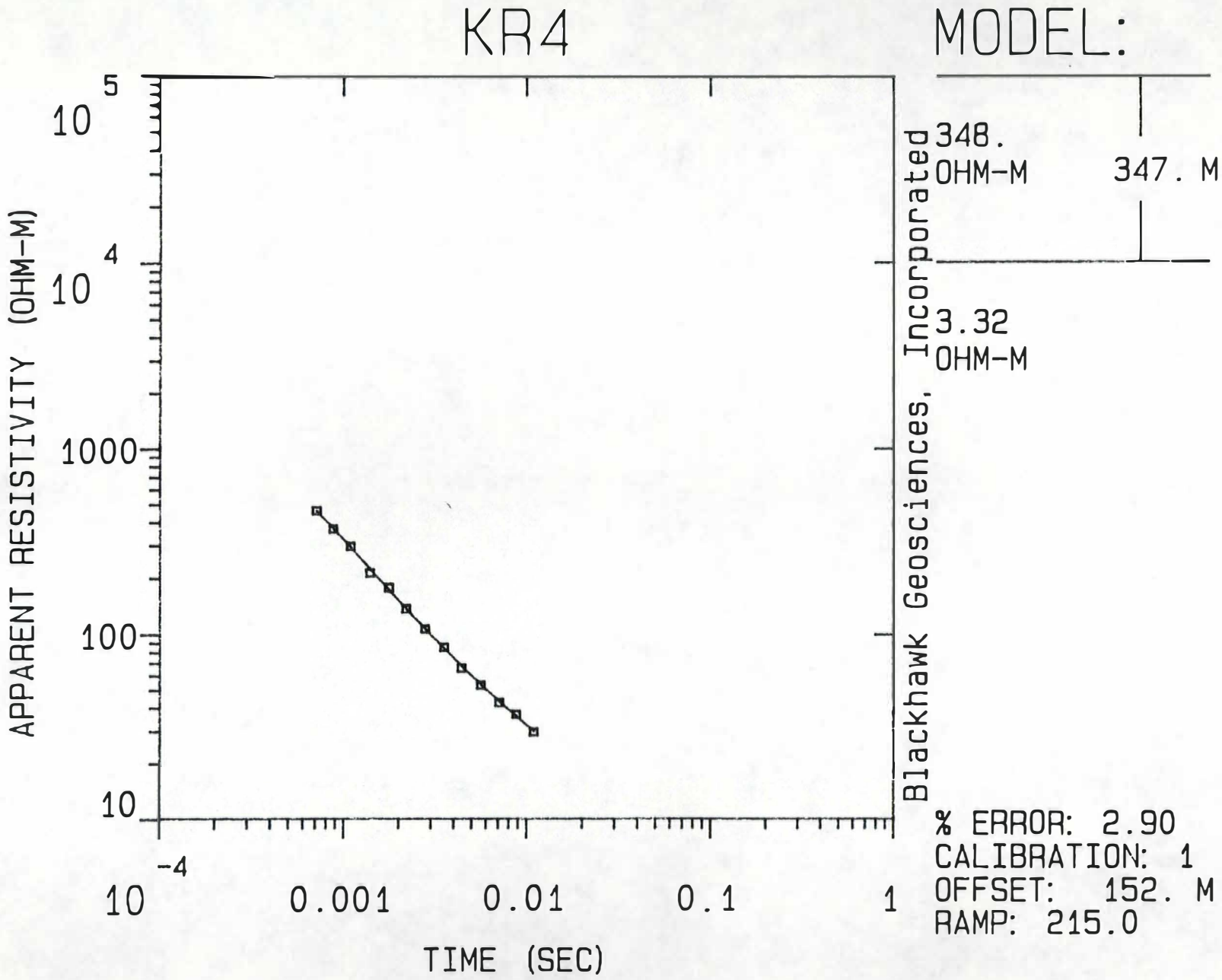
R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 22 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR3
0604 0003 0003 Z OPR XTL H 4 8-100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 2.30E-02, ANTILOG YIELDS 5.4335 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.96				
P 2	0.00	0.01			
P 3	0.05	0.00	0.70		
P 4	0.00	0.00	0.00	0.00	
T 1	-0.07	-0.06	0.10	0.00	0.87

T 2	0.03	0.03	-0.01	0.00	0.04	0.98	
T 3	0.06	-0.01	-0.35	0.00	0.11	-0.01	0.59
	P 1	P 2	P 3	P 4	T 1	T 2	T 3


KR4
MODEL:
348.
OHM-M
347. M
3.32
OHM-M
APPARENT RESISTIVITY (OHM-M)
10 5
10 4
1000
100
10
10 -4
0.001
0.01
0.1
1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 2.90
CALIBRATION: 1
OFFSET: 152. M
RAMP: 215.0

KR4

MODEL: 2 LAYERS

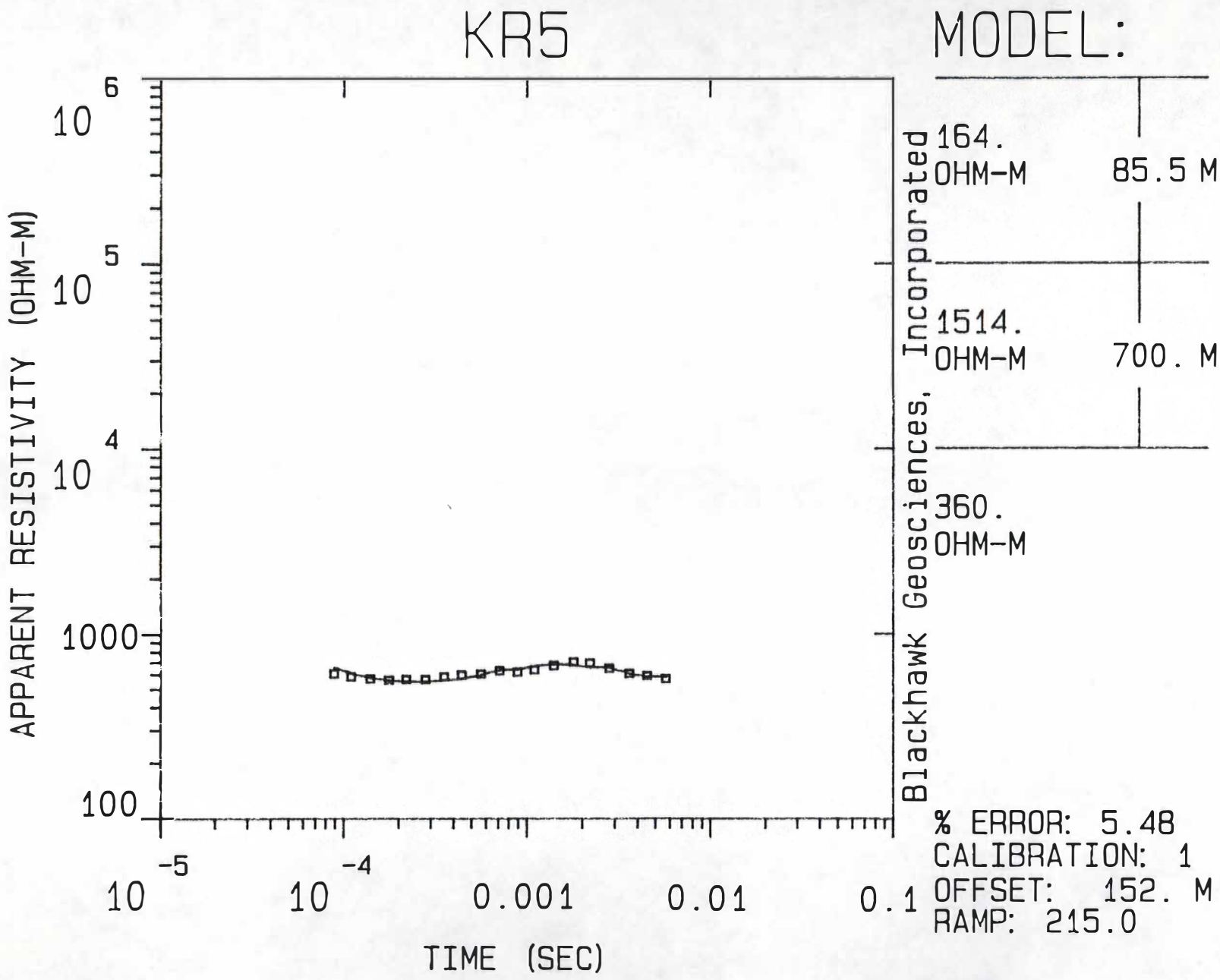
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		356.6	1170.0		
348.38	347.3	9.4	30.7	1.0	1.0
3.32					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	7.13E-04	4.61E+02	4.60E+02	0.196	
2	8.81E-04	3.68E+02	3.69E+02	-0.275	
3	1.10E-03	2.96E+02	2.93E+02	1.126	
4	1.40E-03	2.14E+02	2.23E+02	-4.045	
5	1.77E-03	1.78E+02	1.73E+02	2.986	
6	2.20E-03	1.37E+02	1.37E+02	0.103	
7	2.80E-03	1.07E+02	1.07E+02	0.338	
8	3.55E-03	8.55E+01	8.37E+01	2.146	
9	4.43E-03	6.58E+01	6.74E+01	-2.490	
10	5.64E-03	5.33E+01	5.35E+01	-0.214	
11	7.13E-03	4.27E+01	4.33E+01	-1.286	
12	8.81E-03	3.69E+01	3.60E+01	2.574	
13	1.10E-02	2.97E+01	3.00E+01	-1.038	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 13 DATA POINTS, RAMP: 215.0 MICROSEC, DATA: KR4
0704 0004 0004 Z OPR XTL H 4 8+100
Ch.21 = 0.215 Ch.22 = 0.089 Ch.23 = 20 Ch.24 =
RMS LOG ERROR: 1.24E-02, ANTILOG YIELDS 2.9037 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.61
P 2 -0.14 0.85
T 1 0.01 0.00 1.00
P 1 P 2 T 1


KR5
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 6
10 5
10 4
1000
100
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
164.
OHM-M
85.5 M
1514.
OHM-M
700. M
360.
OHM-M
% ERROR: 5.48
CALIBRATION: 1
OFFSET: 152. M
RAMP: 215.0

KR5

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		615.7	2020.0		
164.41	85.5	530.2	1739.6	0.5	0.5
1514.09	700.0	-169.8	-557.0	0.5	1.0
360.19					

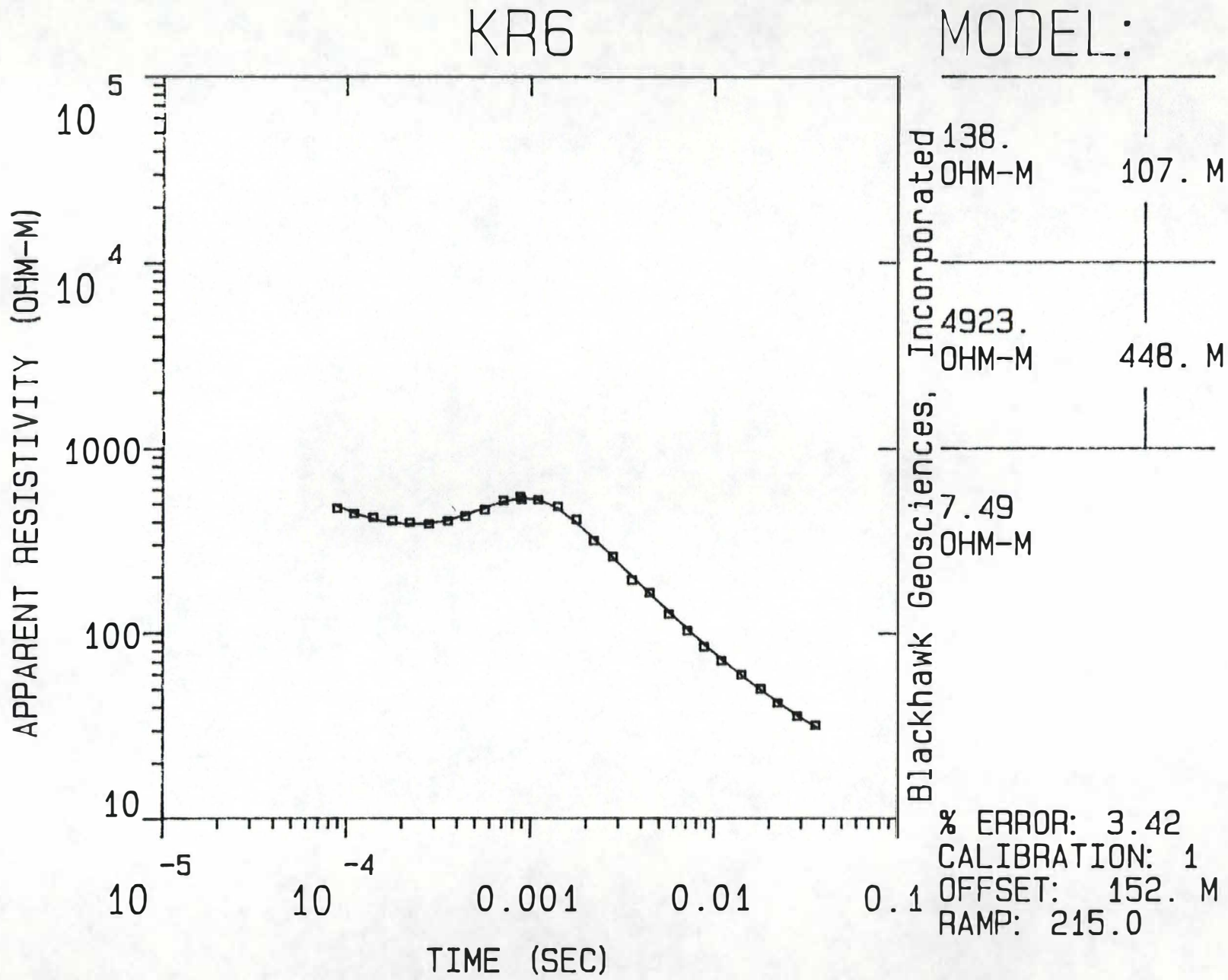
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	6.07E+02	6.55E+02	-7.258	
2	1.10E-04	5.84E+02	6.09E+02	-3.982	
3	1.40E-04	5.69E+02	5.74E+02	-0.805	
4	1.77E-04	5.61E+02	5.56E+02	0.965	
5	2.20E-04	5.65E+02	5.47E+02	3.330	
6	2.80E-04	5.65E+02	5.48E+02	3.017	
7	3.55E-04	5.86E+02	5.63E+02	4.092	
8	4.43E-04	5.98E+02	5.72E+02	4.446	
9	5.64E-04	6.06E+02	6.01E+02	0.811	
10	7.13E-04	6.32E+02	6.39E+02	-1.186	
11	8.90E-04	6.20E+02	6.42E+02	-3.526	
12	1.10E-03	6.38E+02	6.70E+02	-4.752	
13	1.40E-03	6.74E+02	6.88E+02	-2.092	
14	1.80E-03	7.05E+02	6.74E+02	4.547	
15	2.20E-03	6.94E+02	6.55E+02	6.052	
16	2.80E-03	6.49E+02	6.58E+02	-1.399	
17	3.60E-03	6.08E+02	6.05E+02	0.518	
18	4.49E-03	5.93E+02	5.83E+02	1.758	
19	5.70E-03	5.71E+02	5.87E+02	-2.809	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 19 DATA POINTS, RAMP: 215.0 MICROSEC, DATA: KR5
0704 0005 0005 Z OPR XTL L 7 10+100
Ch.21 = 0.215 Ch.22 = 0.89 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 2.32E-02, ANTILOG YIELDS 5.4789 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	1.00				
P 2	0.00	0.98			
P 3	0.00	-0.01	0.99		
T 1	0.00	-0.01	0.00	1.00	
T 2	0.00	0.01	0.01	0.00	0.99
	P 1	P 2	P 3	T 1	T 2


KR6
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
138.
OHM-M
107. M
4923.
OHM-M
448. M
7.49
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.42
CALIBRATION: 1
OFFSET: 152. M
RAMP: 215.0

KR6

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		472.4	1550.0		
137.73	106.8	365.6	1199.5	0.8	0.8
4923.37	448.4	-82.8	-271.6	0.1	0.9
7.49					

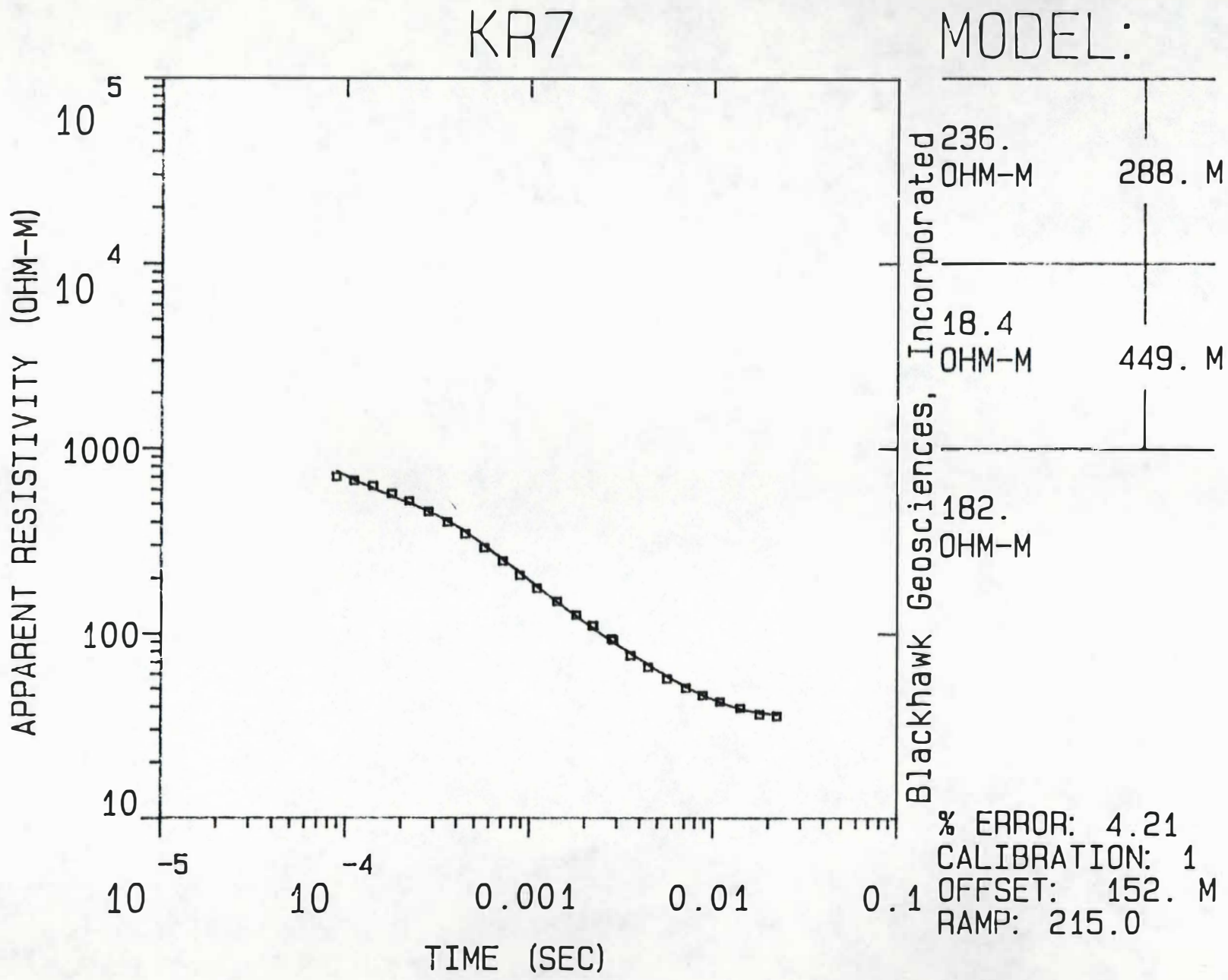
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	4.74E+02	4.91E+02	-3.417	
2	1.10E-04	4.44E+02	4.46E+02	-0.377	
3	1.40E-04	4.23E+02	4.12E+02	2.729	
4	1.77E-04	4.05E+02	3.94E+02	2.795	
5	2.20E-04	3.97E+02	3.88E+02	2.339	
6	2.80E-04	3.90E+02	3.93E+02	-0.826	
7	3.55E-04	4.05E+02	4.11E+02	-1.413	
8	4.43E-04	4.32E+02	4.39E+02	-1.683	
9	5.64E-04	4.69E+02	4.80E+02	-2.138	
10	7.13E-04	5.25E+02	5.20E+02	0.939	
11	8.81E-04	5.52E+02	5.41E+02	1.980	
12	8.90E-04	5.30E+02	5.42E+02	-2.124	
13	1.10E-03	5.29E+02	5.29E+02	-0.023	
14	1.40E-03	4.85E+02	4.71E+02	2.928	
15	1.77E-03	4.13E+02	3.93E+02	5.208	
16	2.20E-03	3.16E+02	3.21E+02	-1.757	
17	2.80E-03	2.59E+02	2.54E+02	1.880	
18	3.55E-03	1.93E+02	2.01E+02	-4.066	
19	4.43E-03	1.65E+02	1.62E+02	1.434	
20	5.64E-03	1.27E+02	1.29E+02	-1.995	
21	7.13E-03	1.03E+02	1.05E+02	-1.622	
22	8.81E-03	8.46E+01	8.70E+01	-2.766	
23	1.10E-02	7.13E+01	7.25E+01	-1.712	
24	1.41E-02	6.00E+01	5.94E+01	1.103	
25	1.80E-02	5.04E+01	4.96E+01	1.752	
26	2.22E-02	4.25E+01	4.26E+01	-0.441	
27	2.85E-02	3.60E+01	3.62E+01	-0.625	
28	3.60E-02	3.21E+01	3.14E+01	2.487	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 28 DATA POINTS, RAMP: 215.0 MICROSEC, DATA: KR6
0704 0006 0006 Z OPR XTL H 3 8+100
Ch.21 = 0.215 Ch.22 = 0.089 Ch.23 = 20 Ch.24 =
RMS LOG ERROR: 1.46E-02, ANTILOG YIELDS 3.4162 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.72				
P 2	0.01	0.00			
P 3	0.02	0.00	0.27		
T 1	-0.35	-0.02	0.07	0.47	
T 2	0.07	0.01	0.02	0.10	0.93
	P 1	P 2	P 3	T 1	T 2


KR7
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
236.
OHM-M
288. M
18.4
OHM-M
449. M
182.
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 4.21
CALIBRATION: 1
OFFSET: 152. M
RAMP: 215.0

KR7

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		509.0	1670.0		
235.95	288.2	220.8	724.5	1.2	1.2
18.43	449.0	-228.1	-748.5	24.4	25.6
181.76					

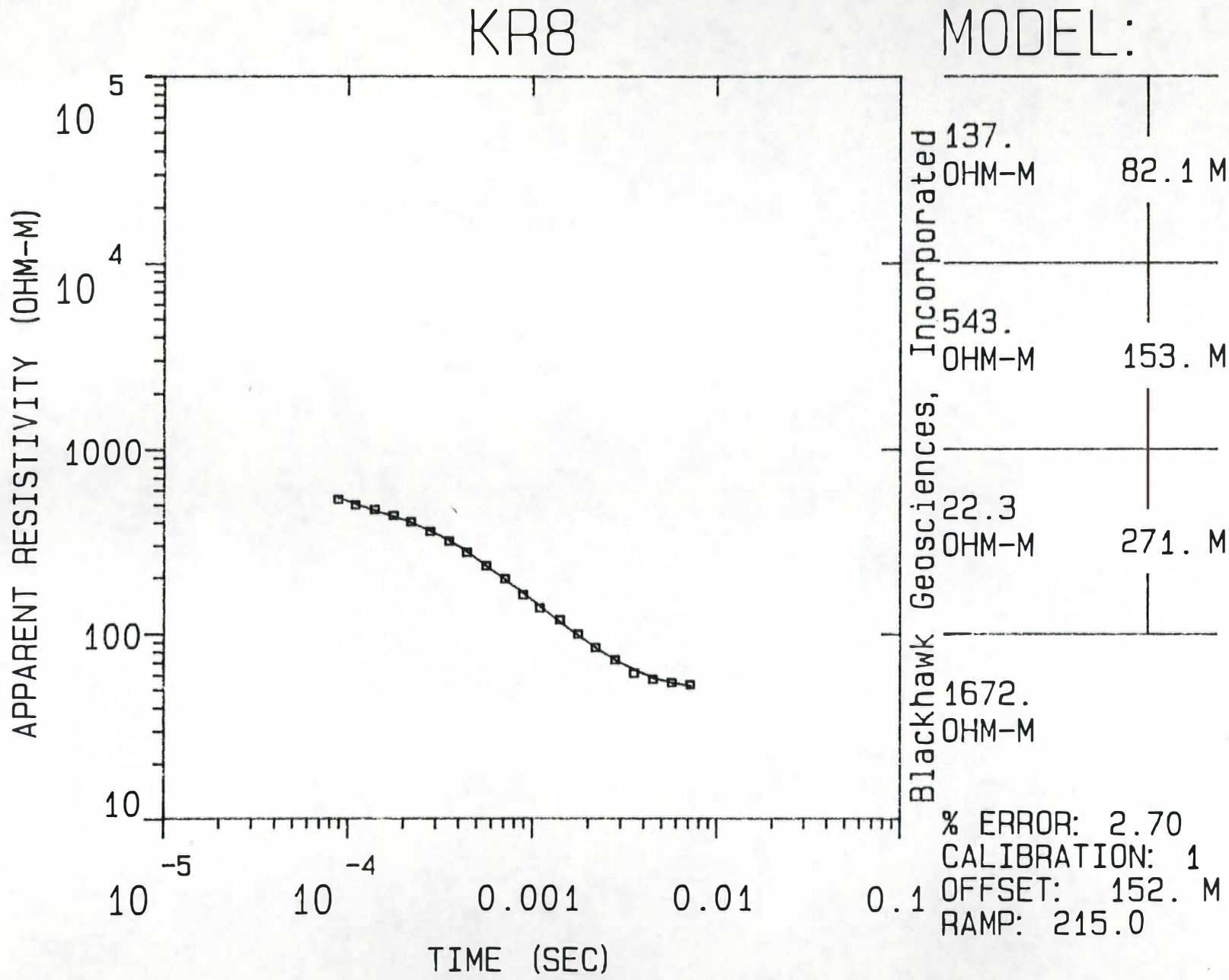
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	7.00E+02	7.50E+02	-6.635	
2	1.10E-04	6.65E+02	6.71E+02	-0.836	
3	1.40E-04	6.23E+02	6.01E+02	3.708	
4	1.77E-04	5.68E+02	5.47E+02	3.915	
5	2.20E-04	5.17E+02	5.02E+02	3.004	
6	2.80E-04	4.53E+02	4.53E+02	-0.039	
7	3.55E-04	3.99E+02	4.03E+02	-1.140	
8	4.43E-04	3.45E+02	3.53E+02	-2.387	
9	5.64E-04	2.89E+02	2.97E+02	-2.623	
10	7.13E-04	2.46E+02	2.50E+02	-1.505	
11	8.81E-04	2.06E+02	2.12E+02	-3.142	
12	1.10E-03	1.75E+02	1.78E+02	-1.498	
13	1.41E-03	1.49E+02	1.46E+02	1.410	
14	1.80E-03	1.26E+02	1.23E+02	2.053	
15	2.20E-03	1.10E+02	1.07E+02	3.589	
16	2.22E-03	1.10E+02	1.06E+02	4.319	
17	2.80E-03	9.34E+01	9.01E+01	3.595	
18	2.85E-03	9.20E+01	8.91E+01	3.307	
19	3.55E-03	7.58E+01	7.77E+01	-2.472	
20	4.43E-03	6.55E+01	6.72E+01	-2.548	
21	5.64E-03	5.66E+01	5.80E+01	-2.567	
22	7.13E-03	5.04E+01	5.11E+01	-1.459	
23	8.81E-03	4.60E+01	4.59E+01	0.285	
24	1.10E-02	4.27E+01	4.21E+01	1.236	
25	1.41E-02	3.94E+01	3.87E+01	1.608	
26	1.80E-02	3.63E+01	3.68E+01	-1.434	
27	2.22E-02	3.56E+01	3.62E+01	-1.631	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 27 DATA POINTS, RAMP: 215.0 MICROSEC, DATA: KR7
0804 0007 0007 Z OPR XTL L 6 10+1000
Ch.21 = 0.215 Ch.22 = 0.89 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 1.79E-02, ANTILOG YIELDS 4.2075 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 1.00

P 2	0.00	1.00			
P 3	0.00	-0.01	0.15		
T 1	0.00	0.00	0.00	1.00	
T 2	0.00	0.00	-0.05	0.00	1.00
	P 1	P 2	P 3	T 1	T 2


KR8
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
137.
OHM-M
82.1 M
543.
OHM-M
153. M
22.3
OHM-M
271. M
1672.
OHM-M
% ERROR: 2.70
CALIBRATION: 1
OFFSET: 152. M
RAMP: 215.0

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		548.6	1800.0		
136.65	82.1	466.6	1530.7	0.6	0.6
542.97	153.5	313.1	1027.1	0.3	0.9
22.30	271.3	41.8	137.1	12.2	13.0
1671.75					

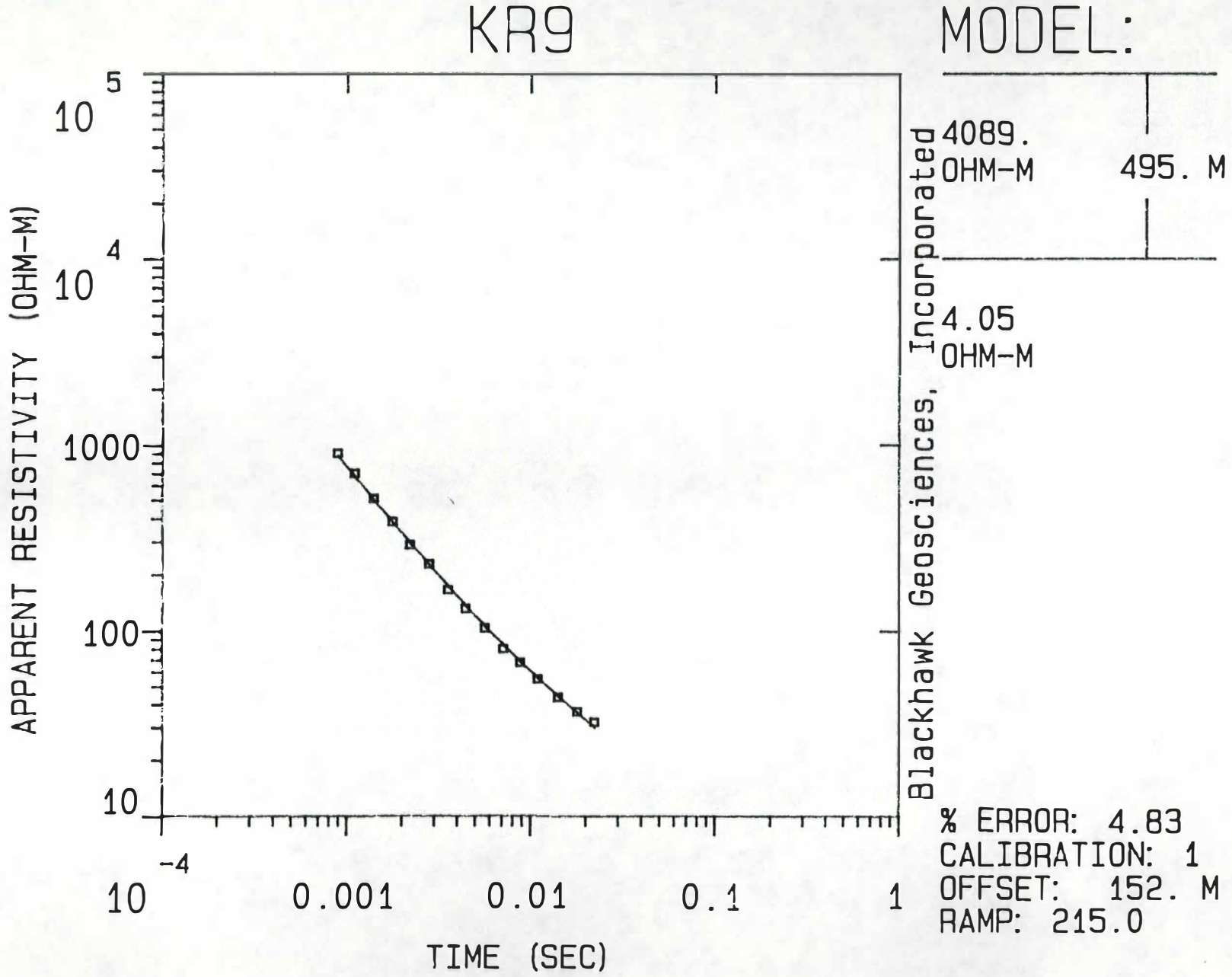
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	5.37E+02	5.50E+02	-2.349	
2	1.10E-04	5.00E+02	5.05E+02	-0.825	
3	1.40E-04	4.71E+02	4.64E+02	1.619	
4	1.77E-04	4.38E+02	4.31E+02	1.490	
5	2.20E-04	4.05E+02	4.01E+02	0.987	
6	2.80E-04	3.58E+02	3.61E+02	-0.779	
7	3.55E-04	3.18E+02	3.19E+02	-0.514	
8	4.43E-04	2.76E+02	2.79E+02	-0.819	
9	5.64E-04	2.33E+02	2.32E+02	0.432	
10	7.13E-04	1.98E+02	1.95E+02	1.337	
11	8.90E-04	1.62E+02	1.66E+02	-2.211	
12	1.10E-03	1.38E+02	1.40E+02	-1.604	
13	1.41E-03	1.19E+02	1.16E+02	3.285	
14	1.77E-03	1.00E+02	9.80E+01	2.141	
15	2.20E-03	8.46E+01	8.43E+01	0.343	
16	2.80E-03	7.27E+01	7.24E+01	0.483	
17	3.55E-03	6.16E+01	6.43E+01	-4.264	
18	4.49E-03	5.73E+01	5.80E+01	-1.254	
19	5.70E-03	5.49E+01	5.45E+01	0.714	
20	7.19E-03	5.35E+01	5.25E+01	1.842	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 20 DATA POINTS, RAMP: 215.0 MICROSEC, DATA: KR8
0804 0008 0008 Z OPR XTL L 7 10+100
Ch.21 = 0.215 Ch.22 = 0.89 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 1.16E-02, ANTILOG YIELDS 2.6954 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.95						
P 2	0.00	0.10					
P 3	0.01	-0.01	0.98				
P 4	0.00	0.00	0.00	0.00			
T 1	-0.10	-0.20	0.02	0.00	0.74		
T 2	0.05	0.15	0.00	0.00	0.12	0.93	
T 3	0.02	-0.04	-0.02	-0.01	0.05	-0.01	0.93


KR9
MODEL:
4089.
OHM-M
495. M
4.05
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 4.83
CALIBRATION: 1
OFFSET: 152. M
RAMP: 215.0
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-4
0.001
0.01
0.1
1
TIME (SEC)

KR9

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		432.8	1420.0		
4089.38	495.1	-62.3	-204.2	0.1	0.1
4.05					

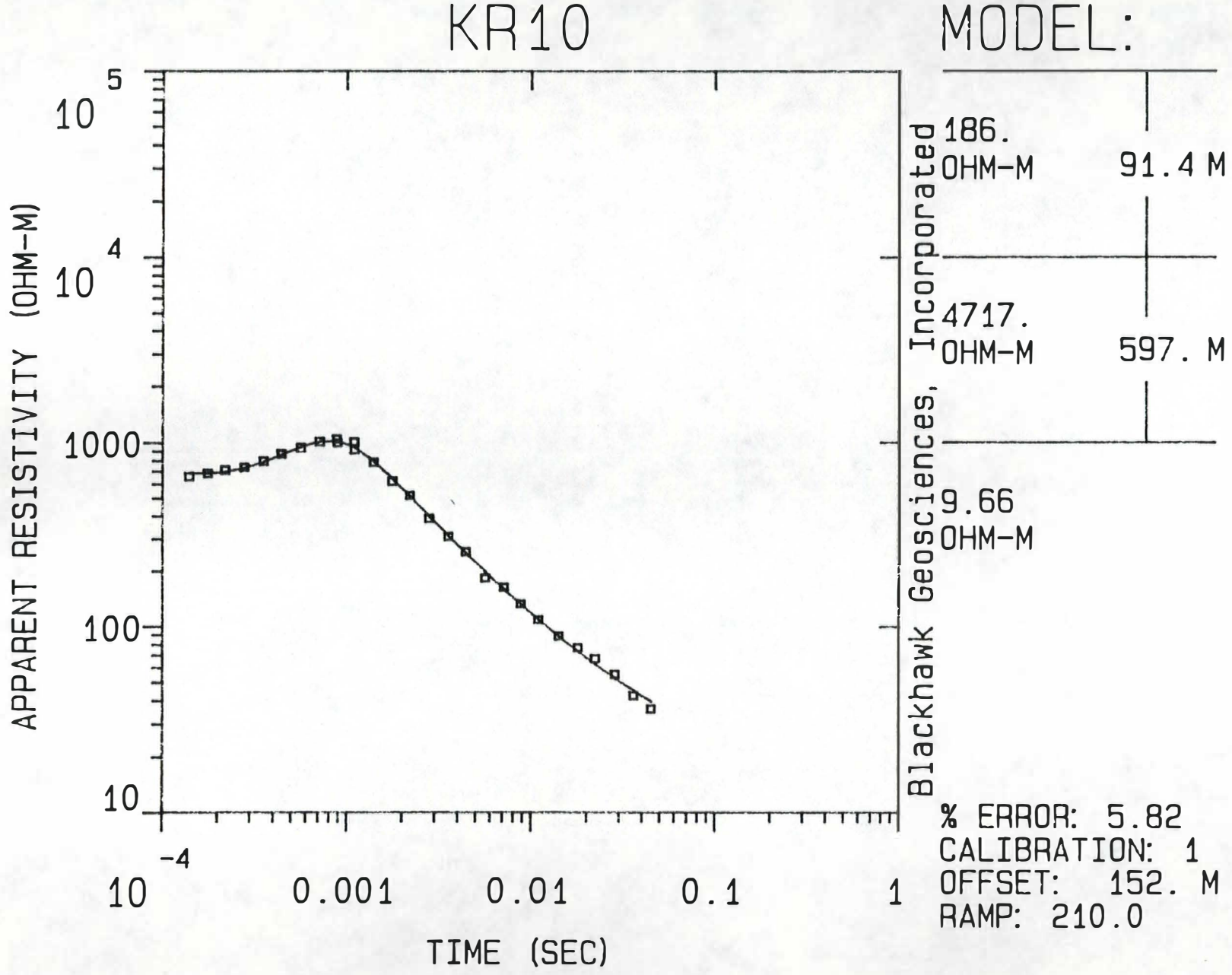
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-04	9.02E+02	8.74E+02	3.236	
2	1.10E-03	7.01E+02	6.75E+02	3.805	
3	1.40E-03	5.14E+02	5.04E+02	1.992	
4	1.77E-03	3.87E+02	3.83E+02	1.232	
5	2.20E-03	2.90E+02	2.97E+02	-2.412	
6	2.80E-03	2.29E+02	2.26E+02	1.432	
7	3.55E-03	1.67E+02	1.74E+02	-4.291	
8	4.43E-03	1.33E+02	1.37E+02	-3.278	
9	5.64E-03	1.04E+02	1.07E+02	-2.270	
10	7.13E-03	8.04E+01	8.43E+01	-4.630	
11	8.81E-03	6.78E+01	6.84E+01	-0.813	
12	1.10E-02	5.55E+01	5.58E+01	-0.535	
13	1.41E-02	4.41E+01	4.43E+01	-0.552	
14	1.80E-02	3.66E+01	3.60E+01	1.774	
15	2.22E-02	3.23E+01	3.01E+01	7.189	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 15 DATA POINTS, RAMP: 215.0 MICROSEC, DATA: KR9
0804 0009 0009 Z OPR XTL L 7 10+100
Ch.21 = 0.215 Ch.22 = 0.89 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 2.05E-02, ANTILOG YIELDS 4.8262 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.04		
P 2	-0.08	0.18	
T 1	-0.02	-0.01	0.98



MODEL:

186. OHM-M

91.4 M

4717. OHM-M

597. M

9.66 OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 5.82
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR10

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		563.9	1850.0		
186.03	91.4	472.5	1550.1	0.5	0.5
4717.11	597.3	-124.8	-409.4	0.1	0.6
9.66					

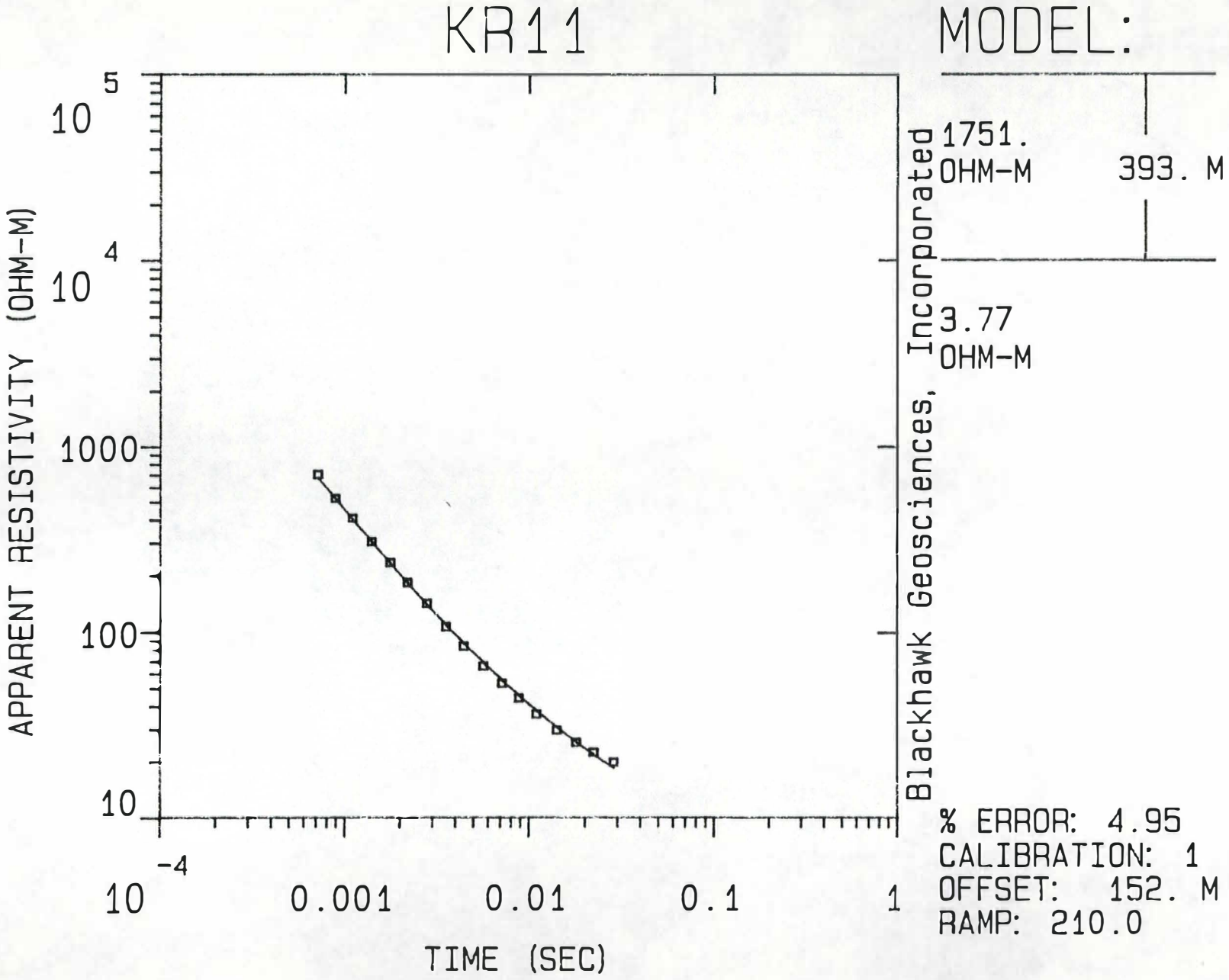
	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.40E-04	6.56E+02	6.87E+02	-4.477	
2	1.77E-04	6.82E+02	6.84E+02	-0.259	
3	2.20E-04	7.13E+02	6.97E+02	2.244	
4	2.80E-04	7.36E+02	7.33E+02	0.349	
5	3.55E-04	7.97E+02	7.90E+02	0.853	
6	4.43E-04	8.72E+02	8.63E+02	1.019	
7	5.64E-04	9.42E+02	9.53E+02	-1.170	
8	7.13E-04	1.02E+03	1.02E+03	-0.275	
9	8.81E-04	1.05E+03	1.02E+03	2.708	
10	8.90E-04	9.97E+02	1.02E+03	-2.127	
11	1.10E-03	1.01E+03	9.43E+02	7.039	
12	1.10E-03	9.17E+02	9.41E+02	-2.515	
13	1.40E-03	7.84E+02	7.91E+02	-0.941	
14	1.77E-03	6.20E+02	6.36E+02	-2.534	
15	2.20E-03	5.18E+02	5.11E+02	1.373	
16	2.80E-03	3.89E+02	3.98E+02	-2.267	
17	3.55E-03	3.10E+02	3.13E+02	-0.852	
18	4.43E-03	2.56E+02	2.51E+02	2.123	
19	5.64E-03	1.84E+02	1.98E+02	-7.257	
20	7.13E-03	1.64E+02	1.59E+02	3.110	
21	8.81E-03	1.33E+02	1.31E+02	1.326	
22	1.10E-02	1.09E+02	1.09E+02	0.423	
23	1.41E-02	8.90E+01	8.82E+01	0.873	
24	1.80E-02	7.71E+01	7.31E+01	5.512	
25	2.22E-02	6.70E+01	6.24E+01	7.454	
26	2.85E-02	5.53E+01	5.25E+01	5.274	
27	3.60E-02	4.27E+01	4.51E+01	-5.369	
28	4.49E-02	3.61E+01	3.95E+01	-8.505	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 28 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR10
0804 0010 0010 Z OPR XTL H 5 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 2.46E-02, ANTILOG YIELDS 5.8237 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.91
P 2 -0.05 0.03
P 3 0.02 -0.01 0.94

T 1	-0.11	-0.12	0.03	0.86	
T 2	0.01	0.02	0.00	0.02	1.00
	P 1	P 2	P 3	T 1	T 2


KR11
MODEL:
1751.
OHM-M
393. M
3.77
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-4
0.001
0.01
0.1
1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 4.95
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR11

MODEL: 2 LAYERS

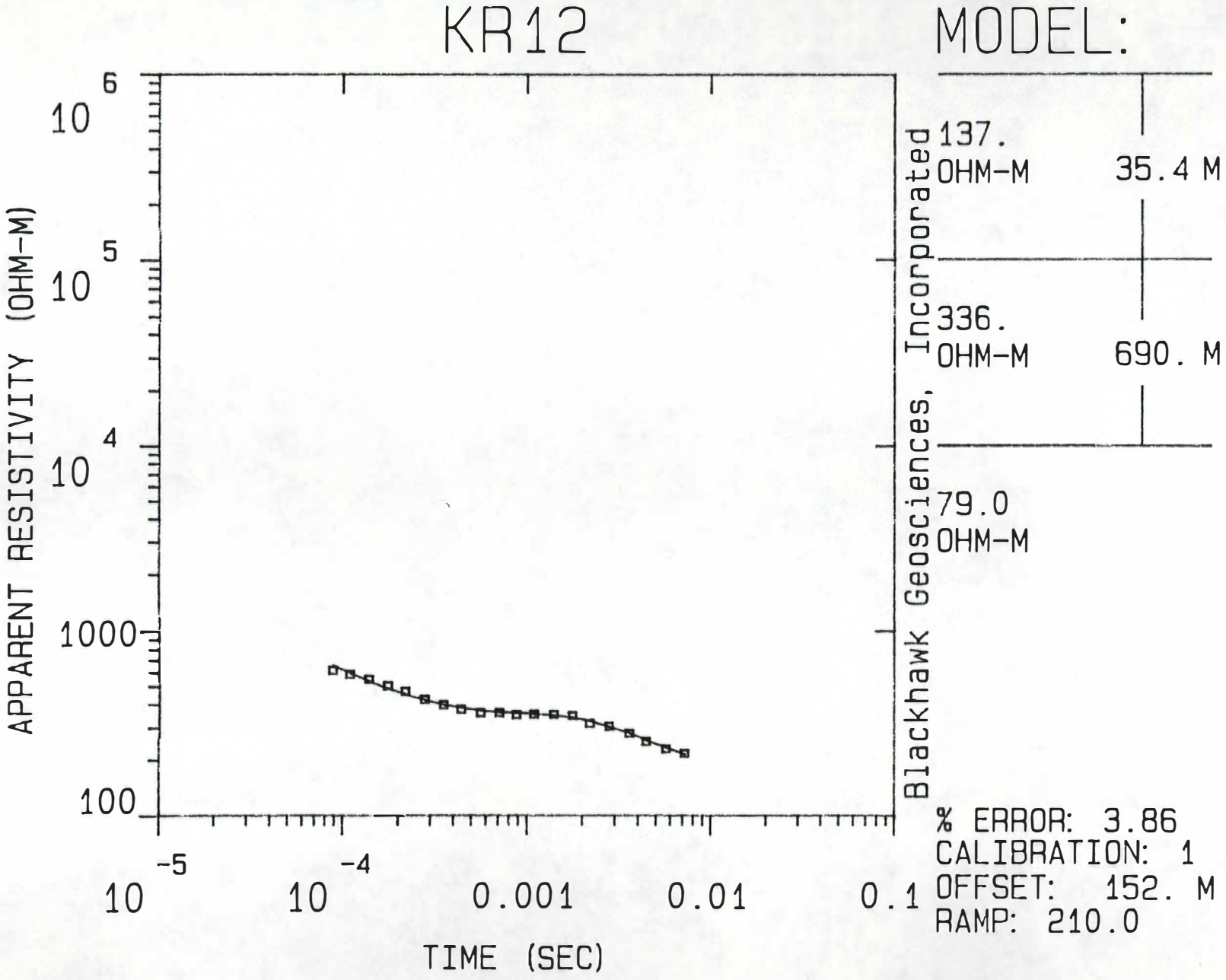
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		378.0	1240.0		
1750.56	392.9	-14.9	-48.9	0.2	0.2
3.77					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	7.13E-04	7.07E+02	6.78E+02	4.260	
2	8.90E-04	5.24E+02	5.19E+02	1.051	
3	1.10E-03	4.09E+02	4.03E+02	1.725	
4	1.40E-03	3.06E+02	3.04E+02	0.521	
5	1.77E-03	2.36E+02	2.33E+02	1.363	
6	2.20E-03	1.84E+02	1.83E+02	0.888	
7	2.80E-03	1.43E+02	1.41E+02	1.899	
8	3.55E-03	1.07E+02	1.09E+02	-1.909	
9	4.43E-03	8.47E+01	8.75E+01	-3.228	
10	5.64E-03	6.61E+01	6.90E+01	-4.216	
11	7.13E-03	5.35E+01	5.53E+01	-3.282	
12	8.81E-03	4.45E+01	4.58E+01	-2.805	
13	1.10E-02	3.65E+01	3.78E+01	-3.614	
14	1.41E-02	2.99E+01	3.08E+01	-3.168	
15	1.80E-02	2.56E+01	2.56E+01	0.117	
16	2.22E-02	2.26E+01	2.18E+01	3.643	
17	2.85E-02	2.00E+01	1.85E+01	8.031	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 17 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR11
0904 0011 0011 Z OPR XTL H 4 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 2.10E-02, ANTILOG YIELDS 4.9522 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.09
P 2 -0.09 0.94
T 1 0.00 0.00 1.00
P 1 P 2 T 1


KR12
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^6
10^5
10^4
1000
100
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
137.
OHM-M
35.4 M
336.
OHM-M
690. M
79.0
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.86
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR12

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		585.2	1920.0		
136.87	35.4	549.8	1803.8	0.3	0.3
335.97	690.5	-140.7	-461.6	2.1	2.3
79.05					

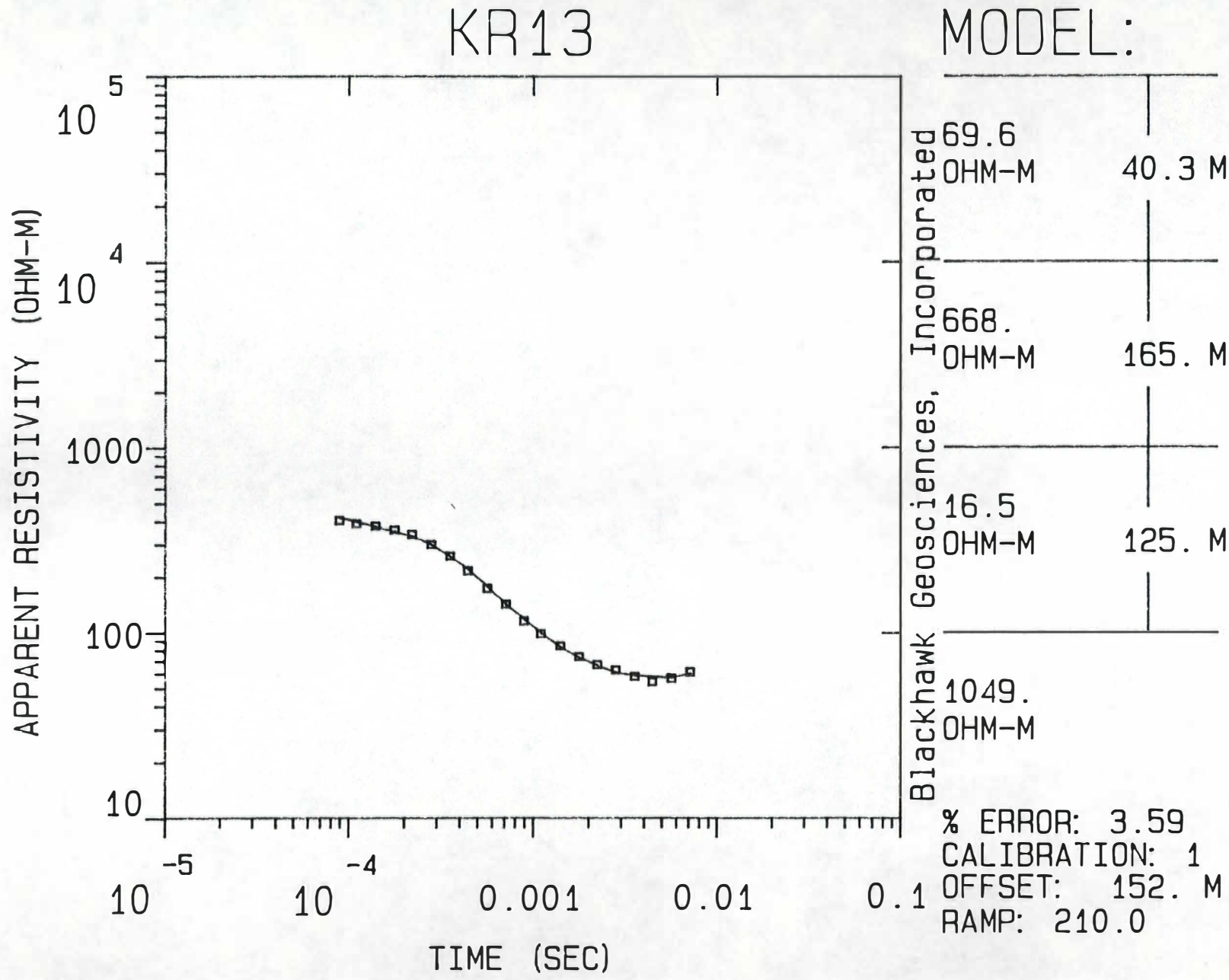
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	6.15E+02	6.55E+02	-6.116	
2	1.10E-04	5.85E+02	5.93E+02	-1.298	
3	1.40E-04	5.51E+02	5.35E+02	2.965	
4	1.77E-04	5.08E+02	4.87E+02	4.319	
5	2.20E-04	4.72E+02	4.54E+02	4.040	
6	2.80E-04	4.28E+02	4.24E+02	1.092	
7	3.55E-04	4.01E+02	4.00E+02	0.279	
8	4.43E-04	3.79E+02	3.86E+02	-1.850	
9	5.64E-04	3.63E+02	3.72E+02	-2.321	
10	7.13E-04	3.63E+02	3.64E+02	-0.346	
11	8.81E-04	3.54E+02	3.61E+02	-1.973	
12	1.10E-03	3.56E+02	3.58E+02	-0.611	
13	1.40E-03	3.55E+02	3.49E+02	1.867	
14	1.77E-03	3.50E+02	3.40E+02	3.002	
15	2.20E-03	3.17E+02	3.27E+02	-2.856	
16	2.80E-03	3.06E+02	3.02E+02	1.339	
17	3.60E-03	2.80E+02	2.81E+02	-0.126	
18	4.43E-03	2.53E+02	2.56E+02	-1.076	
19	5.70E-03	2.30E+02	2.34E+02	-1.638	
20	7.19E-03	2.18E+02	2.14E+02	1.678	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 20 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR12
0904 0012 0012 Z OPR XTL H 4 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 1.64E-02, ANTILOG YIELDS 3.8581 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	0.58				
P 2	0.10	0.89			
P 3	0.02	-0.04	0.15		
T 1	-0.30	-0.08	-0.02	0.21	
T 2	-0.04	0.06	0.17	0.06	0.83



MODEL:

69.6 OHM-M — 40.3 M

668. OHM-M — 165. M

16.5 OHM-M — 125. M

1049. OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 3.59
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR13

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		512.1	1680.0		
69.65	40.3	471.8	1547.8	0.6	0.6
668.05	165.3	306.5	1005.6	0.2	0.8
16.48	125.0	181.5	595.4	7.6	8.4
1049.02					

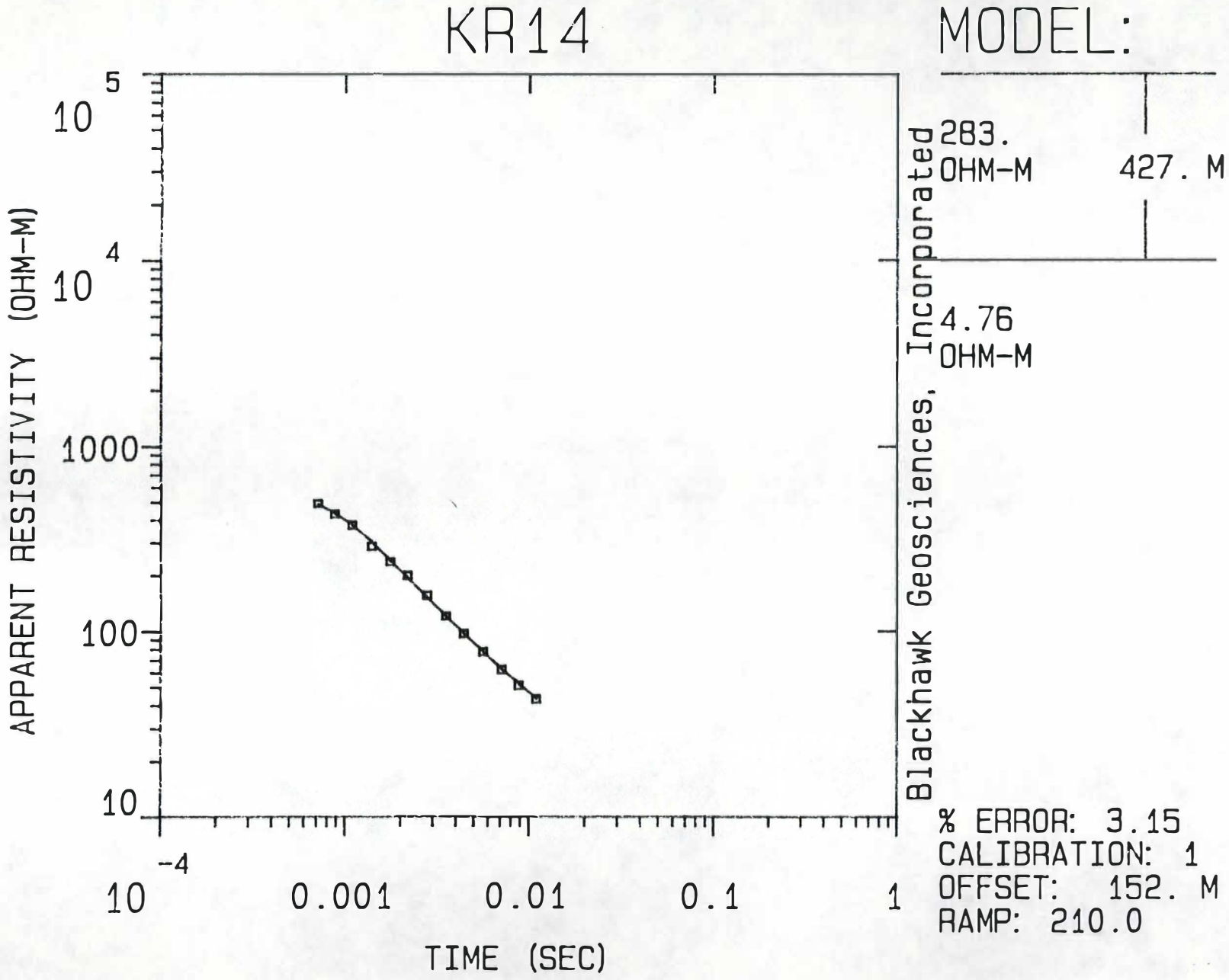
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	4.06E+02	4.24E+02	-4.287	
2	1.10E-04	3.90E+02	3.97E+02	-1.776	
3	1.40E-04	3.78E+02	3.73E+02	1.238	
4	1.77E-04	3.61E+02	3.52E+02	2.493	
5	2.20E-04	3.40E+02	3.32E+02	2.655	
6	2.80E-04	3.01E+02	3.00E+02	0.369	
7	3.55E-04	2.61E+02	2.58E+02	1.184	
8	4.43E-04	2.17E+02	2.21E+02	-1.913	
9	5.64E-04	1.75E+02	1.78E+02	-2.066	
10	7.13E-04	1.43E+02	1.42E+02	0.712	
11	8.90E-04	1.16E+02	1.19E+02	-2.175	
12	1.10E-03	9.92E+01	9.96E+01	-0.368	
13	1.40E-03	8.50E+01	8.34E+01	1.908	
14	1.77E-03	7.43E+01	7.30E+01	1.735	
15	2.22E-03	6.72E+01	6.62E+01	1.478	
16	2.80E-03	6.30E+01	6.05E+01	4.074	
17	3.55E-03	5.81E+01	5.85E+01	-0.695	
18	4.43E-03	5.44E+01	5.75E+01	-5.408	
19	5.64E-03	5.70E+01	5.71E+01	-0.105	
20	7.13E-03	6.16E+01	6.07E+01	1.577	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 20 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR13
0904 0013 0013 Z OPR XTL L 7 10+100
Ch.21 = 0.21 Ch.22 = 0.89 Ch.23 = 20 Ch.24 = 93
RMS LOG ERROR: 1.53E-02, ANTILOG YIELDS 3.5873 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.91						
P 2	0.00	0.05					
P 3	0.03	-0.04	0.90				
P 4	0.00	0.00	-0.01	0.01			
T 1	-0.12	-0.15	0.05	0.00	0.80		
T 2	0.02	0.07	0.02	0.00	0.03	0.98	
T 3	0.04	-0.06	-0.12	-0.03	0.06	0.02	0.84
	P 1	P 2	P 3	P 4	T 1	T 2	T 3


KR14
MODEL:
283.
OHM-M
427. M
4.76
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-4
0.001
0.01
0.1
1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 3.15
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR14

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		464.8	1525.0		
282.58	427.0	37.9	124.2	1.5	1.5
4.76					

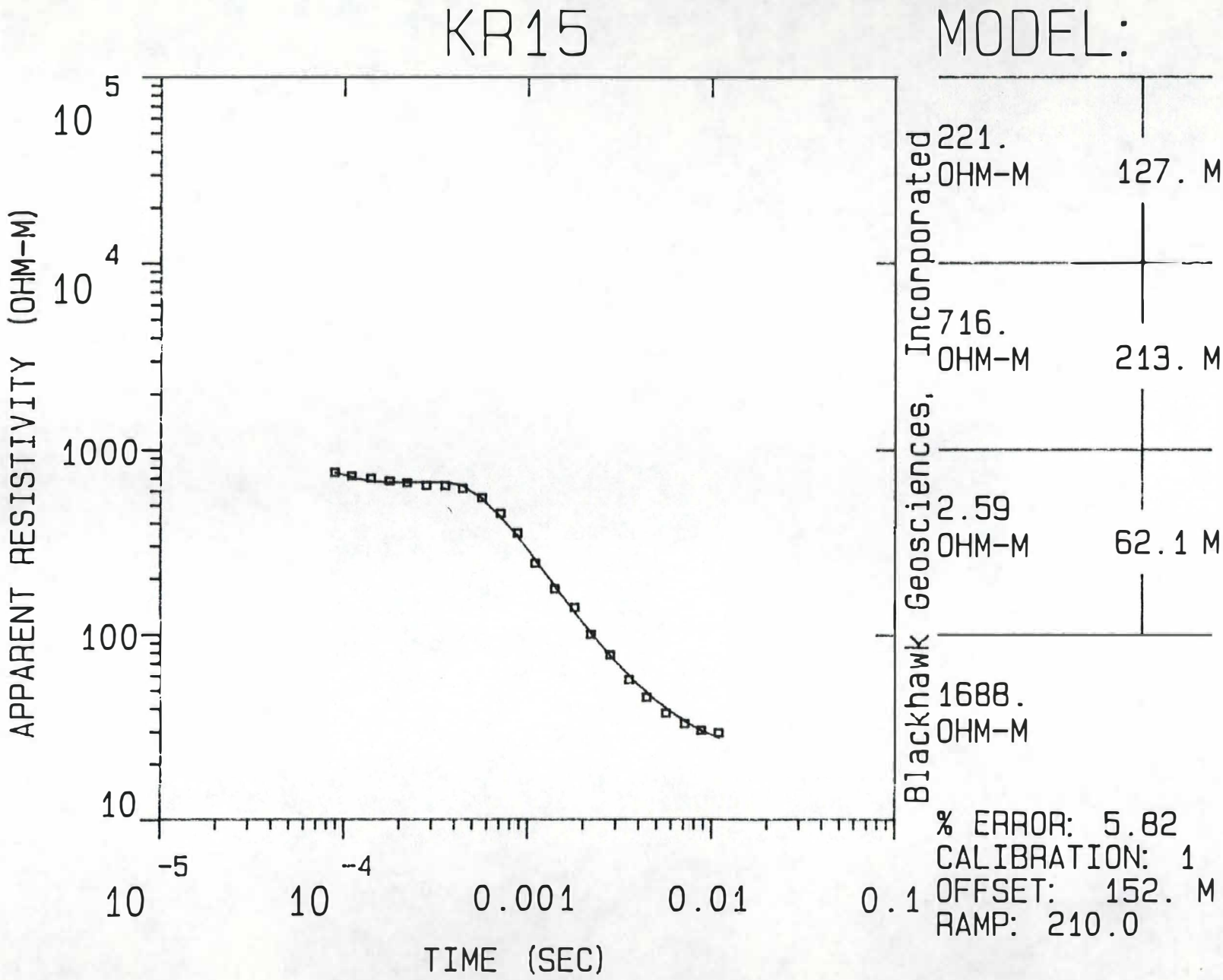
	TIMES	DATA	CALC	% ERROR	STD ERR
1	7.13E-04	4.92E+02	4.89E+02	0.676	
2	8.81E-04	4.31E+02	4.34E+02	-0.749	
3	1.10E-03	3.76E+02	3.75E+02	0.342	
4	1.40E-03	2.87E+02	3.03E+02	-5.317	
5	1.77E-03	2.36E+02	2.38E+02	-0.614	
6	2.20E-03	1.99E+02	1.92E+02	3.572	
7	2.80E-03	1.56E+02	1.51E+02	2.733	
8	3.55E-03	1.20E+02	1.19E+02	0.776	
9	4.43E-03	9.70E+01	9.66E+01	0.354	
10	5.64E-03	7.74E+01	7.74E+01	0.041	
11	7.13E-03	6.22E+01	6.24E+01	-0.458	
12	8.81E-03	5.12E+01	5.22E+01	-1.845	
13	1.10E-02	4.35E+01	4.36E+01	-0.323	

R: 152. X: 0. Y: 153. DL: 305. REC: 170. CF: 1.0000
TDHZ ARRAY, 13 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR14
1004 0014 0014 Z OPR XTL H 4 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 1.35E-02, ANTILOG YIELDS 3.1468 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.98		
P 2	-0.04	0.86	
T 1	0.00	0.00	1.00


KR15
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
MODEL:
221.
OHM-M
127. M
716.
OHM-M
213. M
2.59
OHM-M
62.1 M
1688.
OHM-M
% ERROR: 5.82
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0
Blackhawk Geosciences, Incorporated

KR15

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		594.4	1950.0		
221.39	127.0	467.4	1533.4	0.6	0.6
715.52	212.9	254.5	834.9	0.3	0.9
2.59	62.1	192.4	631.2	24.0	24.9
1687.80					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	7.56E+02	7.59E+02	-0.405	
2	1.10E-04	7.22E+02	7.08E+02	2.028	
3	1.40E-04	7.02E+02	6.73E+02	4.243	
4	1.77E-04	6.77E+02	6.61E+02	2.531	
5	2.20E-04	6.63E+02	6.64E+02	-0.114	
6	2.80E-04	6.40E+02	6.69E+02	-4.337	
7	3.55E-04	6.39E+02	6.66E+02	-3.917	
8	4.43E-04	6.18E+02	6.37E+02	-3.055	
9	5.64E-04	5.49E+02	5.42E+02	1.434	
10	7.13E-04	4.52E+02	4.29E+02	5.417	
11	8.81E-04	3.53E+02	3.38E+02	4.494	
12	1.10E-03	2.43E+02	2.50E+02	-3.088	
13	1.40E-03	1.77E+02	1.81E+02	-2.493	
14	1.80E-03	1.41E+02	1.31E+02	7.033	
15	2.20E-03	1.01E+02	1.02E+02	-1.429	
16	2.80E-03	7.84E+01	7.72E+01	1.536	
17	3.55E-03	5.77E+01	6.03E+01	-4.320	
18	4.43E-03	4.64E+01	4.89E+01	-5.189	
19	5.64E-03	3.81E+01	4.02E+01	-5.071	
20	7.13E-03	3.34E+01	3.44E+01	-2.823	
21	8.81E-03	3.08E+01	3.04E+01	1.162	
22	1.10E-02	2.98E+01	2.80E+01	6.486	

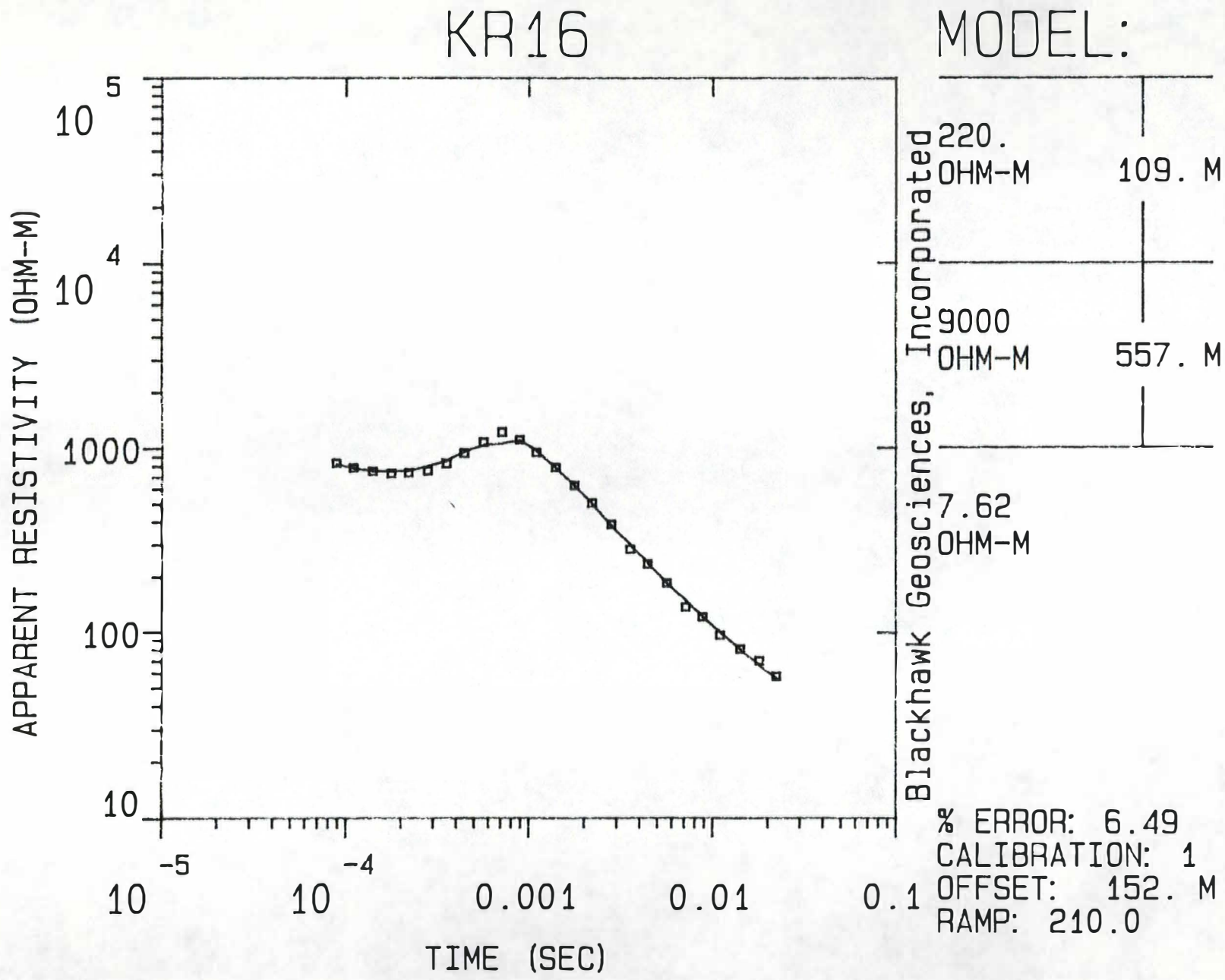
R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 22 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR15
1004 0015 0015 Z OPR XTL H 6 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 2.46E-02, ANTILOG YIELDS 5.8206 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.82				
P 2	0.08	0.02			
P 3	-0.01	-0.01	0.49		
P 4	0.00	0.00	0.00	0.00	
T 1	-0.25	-0.05	0.05	0.00	0.37

T 2	0.13	0.03	-0.01	0.00	0.34	0.76	
T 3	0.01	-0.01	-0.32	0.00	0.05	0.05	0.31
	P 1	P 2	P 3	P 4	T 1	T 2	T 3


KR16
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
220.
OHM-M
109. M
9000
OHM-M
557. M
7.62
OHM-M
% ERROR: 6.49
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

KR16

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		576.1	1890.0		
219.63	109.1	467.0	1532.2	0.5	0.5
9000.00	556.9	-89.8	-294.8	0.1	0.6
7.62					

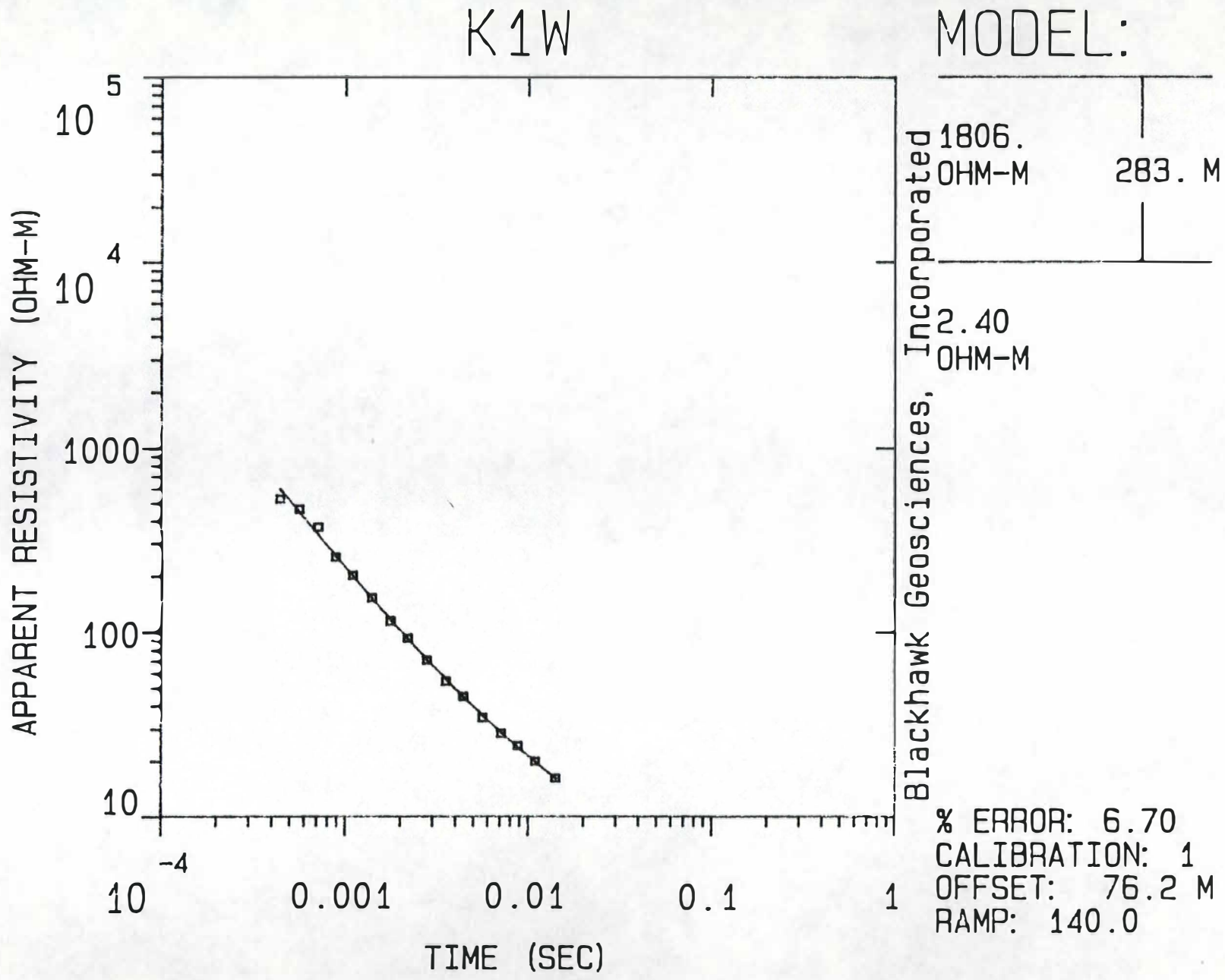
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	8.30E+02	8.20E+02	1.241	
2	1.10E-04	7.81E+02	7.77E+02	0.452	
3	1.40E-04	7.50E+02	7.51E+02	-0.099	
4	1.77E-04	7.30E+02	7.45E+02	-2.044	
5	2.20E-04	7.37E+02	7.61E+02	-3.234	
6	2.80E-04	7.54E+02	8.02E+02	-6.057	
7	3.55E-04	8.29E+02	8.59E+02	-3.495	
8	4.43E-04	9.43E+02	9.62E+02	-1.949	
9	5.64E-04	1.08E+03	1.04E+03	3.482	
10	7.13E-04	1.22E+03	1.06E+03	14.882	
11	8.90E-04	1.11E+03	1.10E+03	0.192	
12	1.10E-03	9.45E+02	9.61E+02	-1.688	
13	1.40E-03	7.84E+02	7.74E+02	1.247	
14	1.77E-03	6.28E+02	6.25E+02	0.537	
15	2.20E-03	5.04E+02	4.98E+02	1.242	
16	2.80E-03	3.87E+02	3.79E+02	2.157	
17	3.55E-03	2.84E+02	2.99E+02	-5.182	
18	4.43E-03	2.36E+02	2.38E+02	-0.958	
19	5.64E-03	1.86E+02	1.85E+02	0.467	
20	7.13E-03	1.38E+02	1.49E+02	-7.451	
21	8.81E-03	1.22E+02	1.21E+02	0.458	
22	1.10E-02	9.67E+01	1.00E+02	-3.340	
23	1.41E-02	8.11E+01	8.05E+01	0.739	
24	1.80E-02	7.03E+01	6.59E+01	6.649	
25	2.22E-02	5.78E+01	5.62E+01	2.893	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
TDHZ ARRAY, 25 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: KR16
1004 0016 0016 Z OPR XTL H 5 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 9
RMS LOG ERROR: 2.73E-02, ANTILOG YIELDS 6.4850 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 1.00
F 2 0.00 0.00
P 3 0.00 0.00 1.00

T 1	0.00	0.00	0.00	1.00	
T 2	0.00	0.00	0.00	0.00	1.00
	P 1	P 2	P 3	T 1	T 2


K1W
MODEL:
1806.
OHM-M
283. M
2.40
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-4
0.001
0.01
0.1
1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 6.70
CALIBRATION: 1
OFFSET: 76.2 M
RAMP: 140.0

K1W

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		253.0	830.0		
1806.08	283.0	-30.0	-98.5	0.2	0.2
2.40					

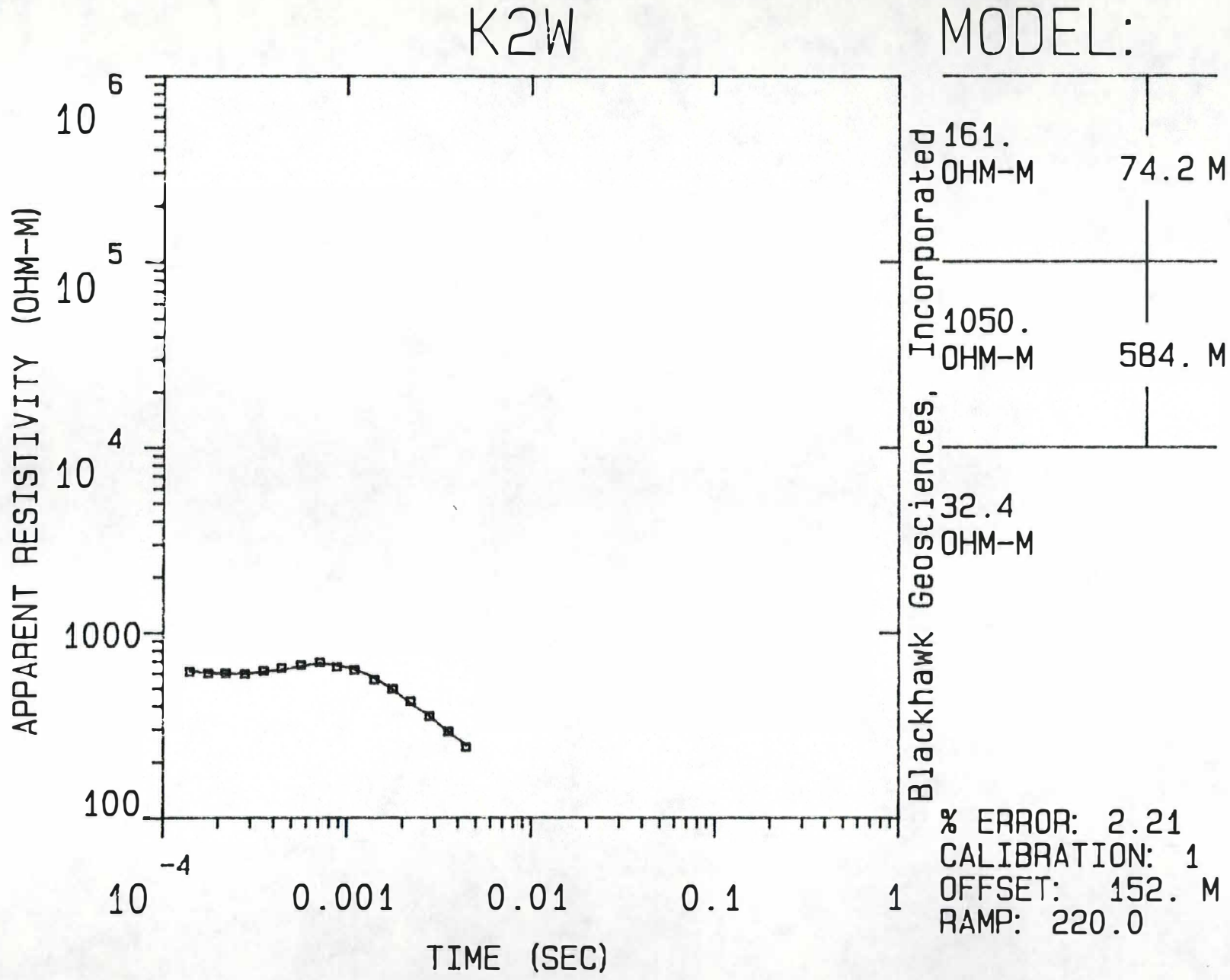
	TIMES	DATA	CALC	% ERROR	STD ERR
1	4.43E-04	5.27E+02	5.95E+02	-11.443	
2	5.64E-04	4.63E+02	4.43E+02	4.585	
3	7.13E-04	3.69E+02	3.33E+02	10.680	
4	8.90E-04	2.54E+02	2.56E+02	-0.770	
5	1.10E-03	2.02E+02	2.00E+02	1.263	
6	1.40E-03	1.53E+02	1.51E+02	1.055	
7	1.77E-03	1.15E+02	1.17E+02	-1.314	
8	2.20E-03	9.32E+01	9.22E+01	1.157	
9	2.80E-03	7.12E+01	7.13E+01	-0.236	
10	3.55E-03	5.49E+01	5.61E+01	-2.131	
11	4.43E-03	4.55E+01	4.49E+01	1.301	
12	5.64E-03	3.49E+01	3.57E+01	-2.234	
13	7.13E-03	2.86E+01	2.88E+01	-0.703	
14	8.81E-03	2.44E+01	2.38E+01	2.589	
15	1.10E-02	2.01E+01	1.98E+01	1.163	
16	1.41E-02	1.63E+01	1.61E+01	1.336	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
TDHZ ARRAY, 16 DATA POINTS, RAMP: 140.0 MICROSEC, DATA: K1W
2304 100N 001W Z OPR XTL H 4 8+100
Ch.21 = 0.14 Ch.22 = 0.089 Ch.23 = 22 Ch.24 = 2
RMS LOG ERROR: 2.81E-02, ANTILOG YIELDS 6.6956 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.33		
P 2	-0.30	0.80	
T 1	-0.02	-0.01	1.00
	P 1	P 2	T 1



MODEL:

161.
OHM-M

74.2 M

1050.
OHM-M

584. M

32.4
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 2.21
CALIBRATION: 1
OFFSET: 152. M
RAMP: 220.0

K2W

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		560.8	1840.0		
160.93	74.2	486.7	1596.7	0.5	0.5
1049.84	584.2	-97.5	-320.0	0.6	1.0
32.40					

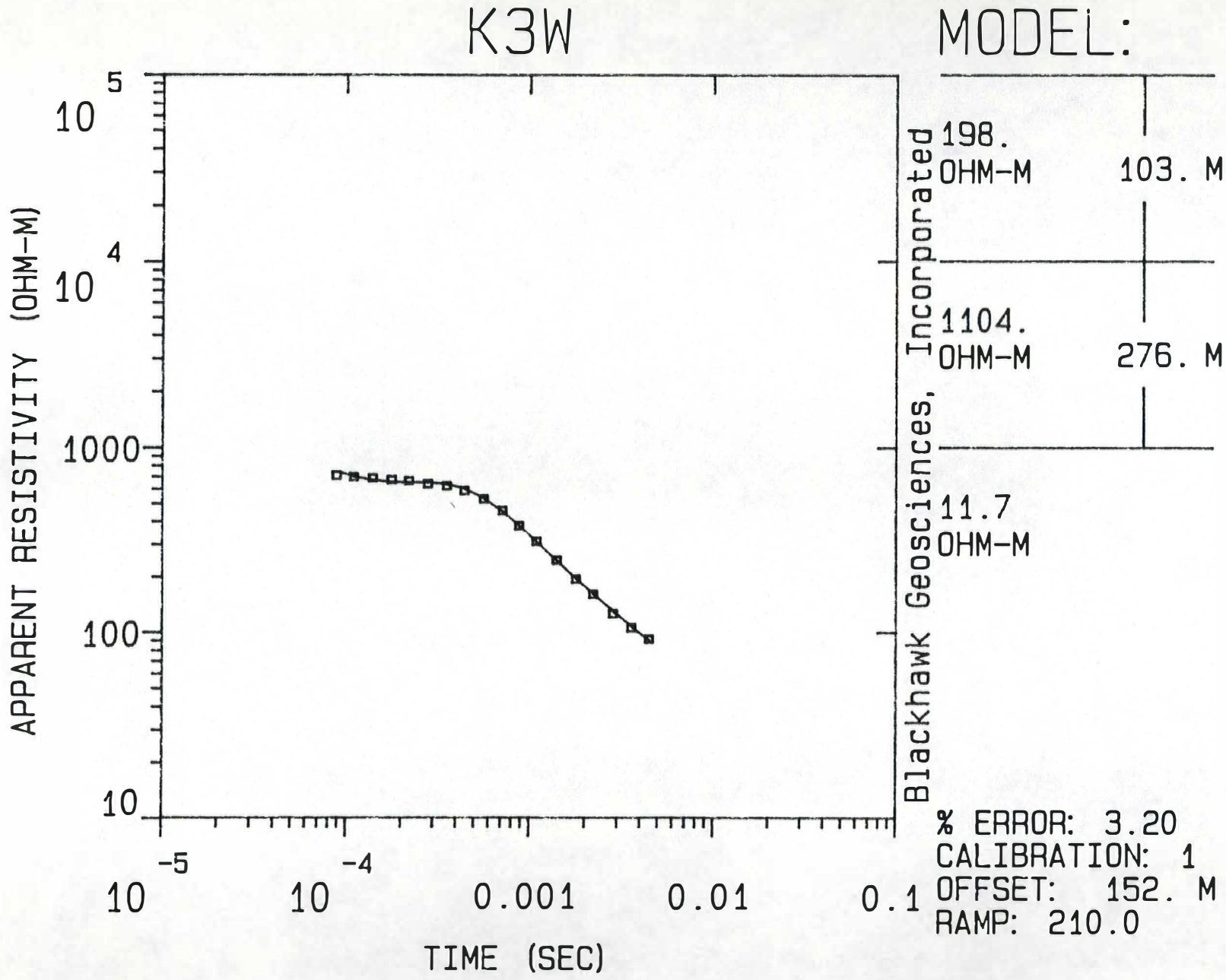
	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.40E-04	6.13E+02	6.22E+02	-1.418	
2	1.77E-04	6.01E+02	6.03E+02	-0.371	
3	2.20E-04	6.02E+02	5.96E+02	0.937	
4	2.80E-04	5.96E+02	5.98E+02	-0.206	
5	3.55E-04	6.20E+02	6.18E+02	0.245	
6	4.43E-04	6.42E+02	6.32E+02	1.560	
7	5.64E-04	6.66E+02	6.59E+02	1.112	
8	7.13E-04	6.90E+02	6.88E+02	0.315	
9	8.81E-04	6.52E+02	6.64E+02	-1.858	
10	1.10E-03	6.27E+02	6.34E+02	-1.107	
11	1.41E-03	5.55E+02	5.67E+02	-2.211	
12	1.77E-03	4.96E+02	4.90E+02	1.296	
13	2.22E-03	4.25E+02	4.11E+02	3.461	
14	2.80E-03	3.52E+02	3.53E+02	-0.192	
15	3.55E-03	2.92E+02	2.89E+02	0.896	
16	4.43E-03	2.41E+02	2.45E+02	-1.755	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 16 DATA POINTS, RAMP: 220.0 MICROSEC, DATA: K2W
2304 100N 002W Z OPR XTL L 6 8+100
Ch.21 = 0.22 Ch.22 = 0.89 Ch.23 = 19 Ch.24 = 92
RMS LOG ERROR: 9.47E-03, ANTILOG YIELDS 2.2050 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	1.00				
P 2	0.00	0.99			
P 3	0.00	0.00	0.99		
T 1	0.00	-0.01	0.00	0.99	
T 2	0.00	0.00	0.00	0.00	1.00


K3W
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
198.
OHM-M
103. M
1104.
OHM-M
276. M
11.7
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.20
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

K3W

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		530.4	1740.0		
198.16	103.0	427.4	1402.1	0.5	0.5
1104.33	276.3	151.0	495.6	0.3	0.8
11.73					

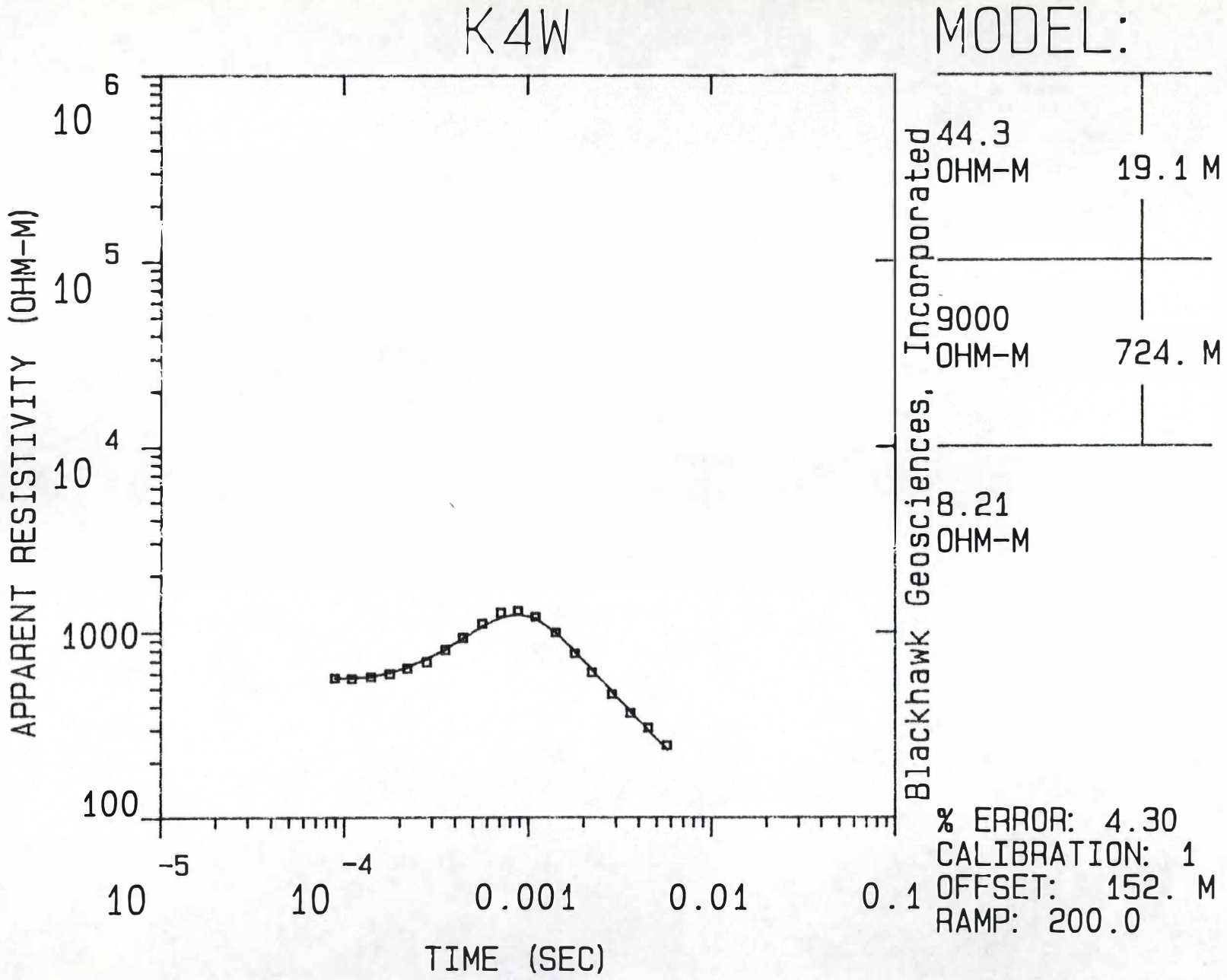
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	7.08E+02	7.44E+02	-4.832	
2	1.10E-04	6.95E+02	6.97E+02	-0.346	
3	1.40E-04	6.86E+02	6.65E+02	3.198	
4	1.77E-04	6.71E+02	6.51E+02	3.158	
5	2.20E-04	6.62E+02	6.47E+02	2.317	
6	2.80E-04	6.36E+02	6.46E+02	-1.557	
7	3.55E-04	6.21E+02	6.33E+02	-1.964	
8	4.43E-04	5.86E+02	5.99E+02	-2.053	
9	5.64E-04	5.28E+02	5.32E+02	-0.677	
10	7.13E-04	4.57E+02	4.50E+02	1.687	
11	8.81E-04	3.78E+02	3.76E+02	0.726	
12	1.10E-03	3.11E+02	3.08E+02	1.148	
13	1.41E-03	2.46E+02	2.43E+02	1.391	
14	1.80E-03	1.94E+02	1.95E+02	-0.143	
15	2.22E-03	1.61E+02	1.61E+02	-0.072	
16	2.85E-03	1.26E+02	1.30E+02	-2.691	
17	3.60E-03	1.06E+02	1.07E+02	-1.252	
18	4.49E-03	9.19E+01	9.03E+01	1.764	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 18 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: K3W
2304 100N 003W Z OPR XTL H 4 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 19.5 Ch.24 =
RMS LOG ERROR: 1.37E-02, ANTILOG YIELDS 3.1982 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.95				
P 2	-0.04	0.08			
P 3	0.03	-0.04	0.86		
T 1	-0.09	-0.22	0.07	0.80	
T 2	0.03	0.10	-0.02	0.07	0.97
	P 1	P 2	P 3	T 1	T 2



MODEL:

44.3 OHM-M

19.1 M

9000 OHM-M

724. M

8.21 OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 4.30
CALIBRATION: 1
OFFSET: 152. M
RAMP: 200.0

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		507.5	1665.0		
44.30	19.1	488.4	1602.4	0.4	0.4
9000.00	723.6	-235.2	-771.5	0.1	0.5
8.21					

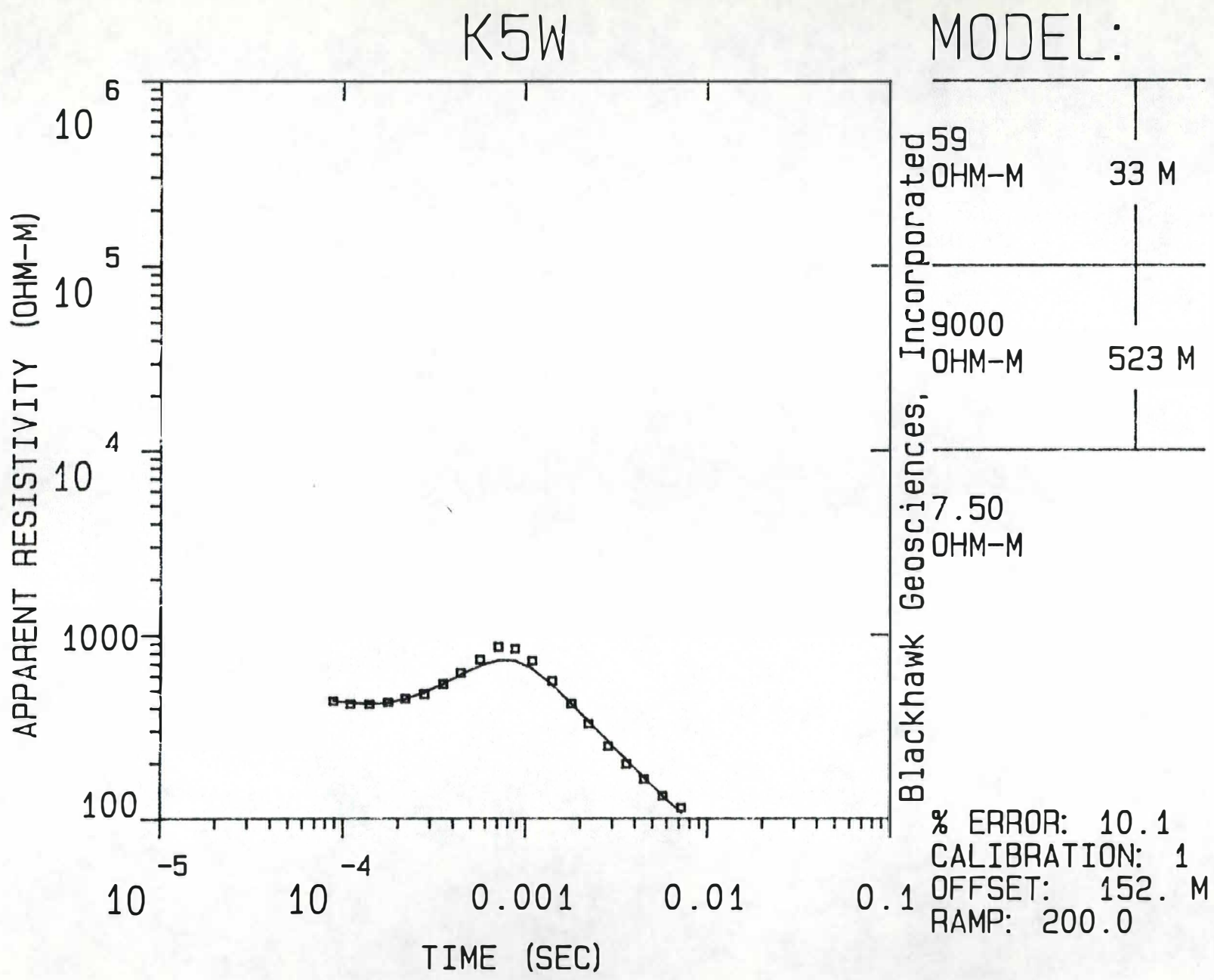
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	5.70E+02	5.73E+02	-0.426	
2	1.10E-04	5.64E+02	5.69E+02	-0.803	
3	1.40E-04	5.76E+02	5.81E+02	-0.951	
4	1.77E-04	5.99E+02	6.11E+02	-1.839	
5	2.20E-04	6.44E+02	6.54E+02	-1.585	
6	2.80E-04	6.95E+02	7.23E+02	-3.839	
7	3.55E-04	8.08E+02	8.18E+02	-1.172	
8	4.43E-04	9.35E+02	9.32E+02	0.358	
9	5.64E-04	1.12E+03	1.08E+03	3.401	
10	7.13E-04	1.27E+03	1.21E+03	5.444	
11	8.81E-04	1.30E+03	1.25E+03	4.102	
12	1.10E-03	1.21E+03	1.18E+03	2.496	
13	1.41E-03	9.93E+02	9.89E+02	0.430	
14	1.80E-03	7.70E+02	7.85E+02	-1.826	
15	2.22E-03	6.10E+02	6.26E+02	-2.565	
16	2.85E-03	4.67E+02	4.80E+02	-2.773	
17	3.60E-03	3.69E+02	3.75E+02	-1.404	
18	4.49E-03	3.08E+02	2.97E+02	3.465	
19	5.70E-03	2.47E+02	2.34E+02	5.821	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 19 DATA POINTS, RAMP: 200.0 MICROSEC, DATA: K4W
2404 100N 004W Z OPR XTL H 4 8+100
Ch.21 = 0.2 Ch.22 = 0.089 Ch.23 = 20 Ch.24 = 92
RMS LOG ERROR: 1.83E-02, ANTILOG YIELDS 4.3042 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.81				
F 2	0.00	0.00			
P 3	0.16	0.00	0.34		
T 1	-0.20	0.00	0.18	0.78	
T 2	0.01	0.00	-0.04	0.01	1.00
	P 1	F 2	P 3	T 1	T 2


K5W
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^6
10^5
10^4
1000
100
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
59
OHM-M
33 M
9000
OHM-M
523 M
7.50
OHM-M
% ERROR: 10.1
CALIBRATION: 1
OFFSET: 152. M
RAMP: 200.0

K5W

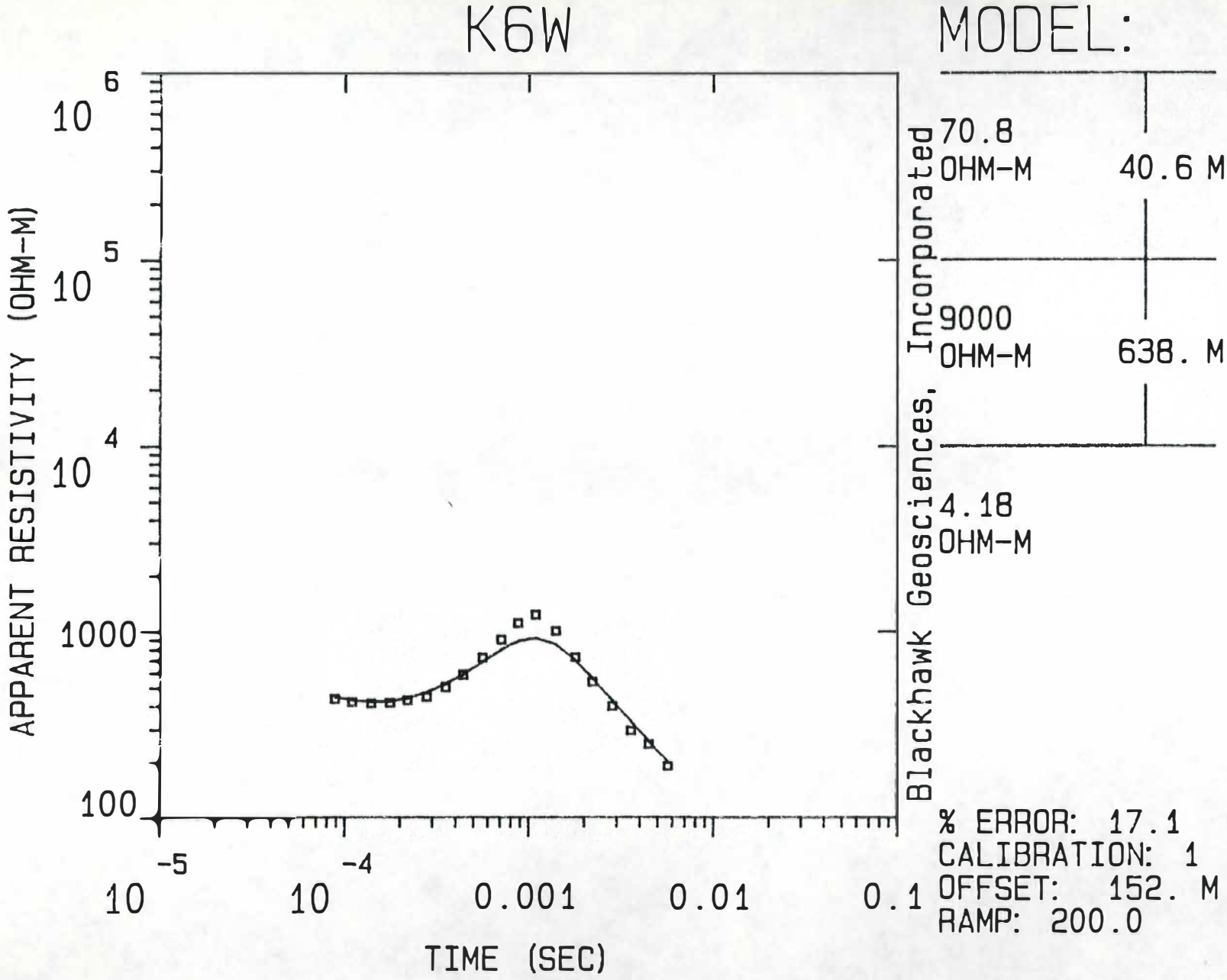
MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		408.4	1340.0		
59.00	33.0	375.4	1231.7	0.6	0.6
9000.00	523.0	-147.6	-484.1	0.1	0.6
7.50					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	4.38E+02	4.42E+02	-0.965	
2	1.10E-04	4.21E+02	4.25E+02	-0.977	
3	1.40E-04	4.20E+02	4.21E+02	-0.054	
4	1.77E-04	4.30E+02	4.30E+02	0.034	
5	2.20E-04	4.53E+02	4.52E+02	0.245	
6	2.80E-04	4.79E+02	4.90E+02	-2.398	
7	3.55E-04	5.42E+02	5.45E+02	-0.578	
8	4.43E-04	6.23E+02	6.10E+02	2.052	
9	5.64E-04	7.36E+02	6.85E+02	7.537	
10	7.13E-04	8.63E+02	7.31E+02	18.025	
11	8.81E-04	8.38E+02	7.20E+02	16.465	
12	1.10E-03	7.23E+02	6.49E+02	11.334	
13	1.41E-03	5.61E+02	5.30E+02	5.907	
14	1.80E-03	4.23E+02	4.20E+02	0.813	
15	2.22E-03	3.28E+02	3.37E+02	-2.711	
16	2.85E-03	2.48E+02	2.62E+02	-5.191	
17	3.60E-03	1.98E+02	2.07E+02	-4.089	
18	4.49E-03	1.64E+02	1.67E+02	-1.441	
19	5.70E-03	1.33E+02	1.33E+02	0.200	
20	7.19E-03	1.15E+02	1.07E+02	6.841	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 20 DATA POINTS, RAMP: 200.0 MICROSEC, DATA: K5W
2404 100N 005W Z OPR XTL H 4 8+100
Ch.21 = 0.2 Ch.22 = 0.089 Ch.23 = 19.5 Ch.24 =
RMS LOG ERROR: 4.17E-02, ANTILOG YIELDS 10.0829 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *
CURRENT RESOLUTION MATRICES NOT AVAILABLE


K6W
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 6
10 5
10 4
1000
100
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
70.8
OHM-M
40.6 M
9000
OHM-M
638. M
4.18
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 17.1
CALIBRATION: 1
OFFSET: 152. M
RAMP: 200.0

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		442.0	1450.0		
70.84	40.6	401.4	1316.8	0.6	0.6
9000.00	638.4	-237.1	-777.8	0.1	0.6
4.18					

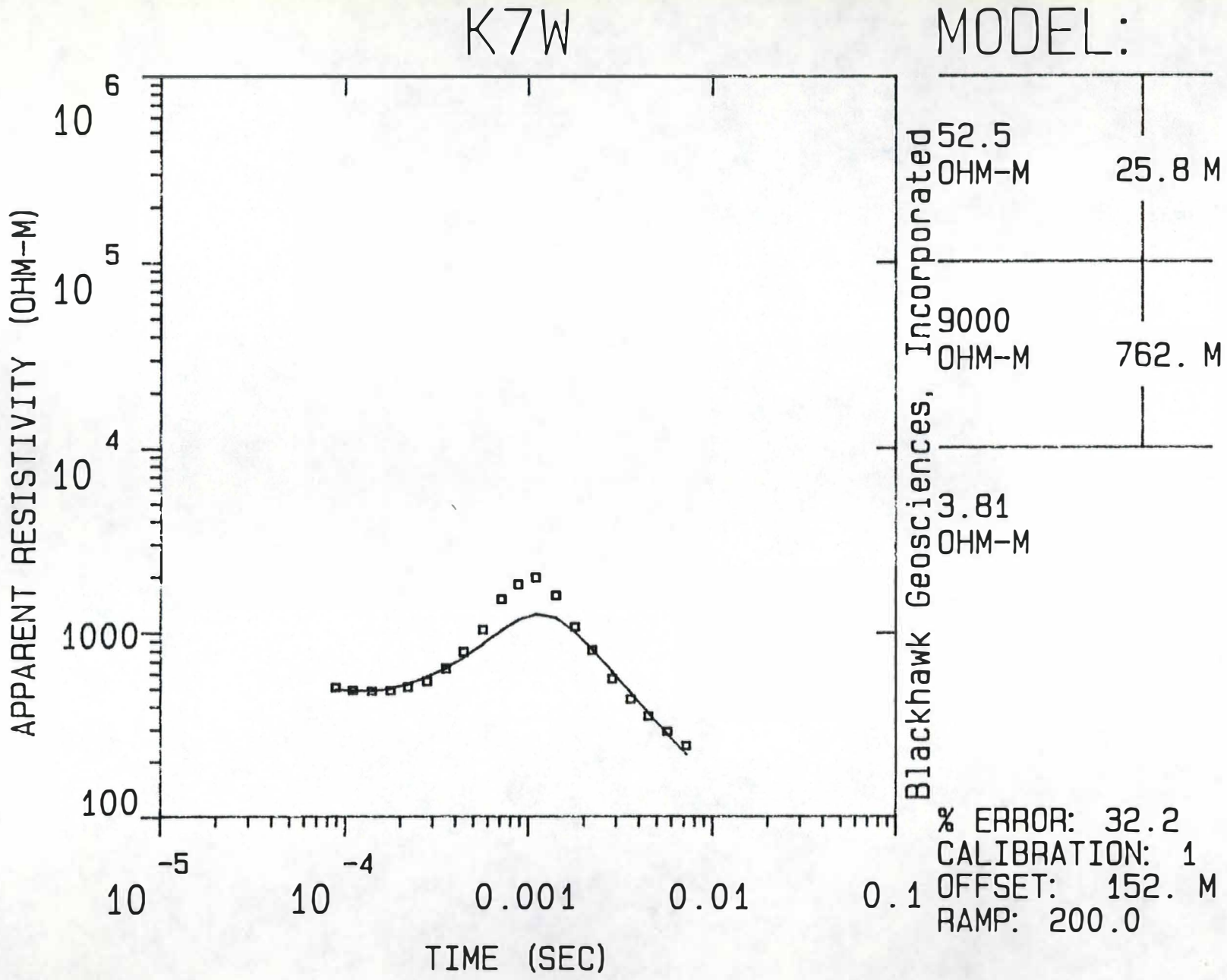
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	4.38E+02	4.51E+02	-2.711	
2	1.10E-04	4.22E+02	4.30E+02	-1.955	
3	1.40E-04	4.15E+02	4.22E+02	-1.714	
4	1.77E-04	4.17E+02	4.28E+02	-2.547	
5	2.20E-04	4.31E+02	4.45E+02	-2.950	
6	2.80E-04	4.50E+02	4.78E+02	-5.773	
7	3.55E-04	5.07E+02	5.29E+02	-3.997	
8	4.43E-04	5.90E+02	5.95E+02	-0.925	
9	5.64E-04	7.29E+02	6.92E+02	5.292	
10	7.13E-04	9.07E+02	8.04E+02	12.776	
11	8.81E-04	1.11E+03	8.94E+02	24.484	
12	1.10E-03	1.24E+03	9.25E+02	33.691	
13	1.41E-03	1.01E+03	8.45E+02	19.116	
14	1.80E-03	7.29E+02	6.97E+02	4.718	
15	2.22E-03	5.40E+02	5.61E+02	-3.682	
16	2.85E-03	4.03E+02	4.28E+02	-5.860	
17	3.60E-03	2.98E+02	3.31E+02	-9.881	
18	4.49E-03	2.52E+02	2.60E+02	-3.053	
19	5.70E-03	1.91E+02	2.01E+02	-4.745	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 19 DATA POINTS, RAMP: 200.0 MICROSEC, DATA: K6W
2404 100N 006W Z OPR XTL H 4 8+100
Ch.21 = 0.2 Ch.22 = 0.089 Ch.23 = 19.5 Ch.24 =
RMS LOG ERROR: 6.84E-02, ANTILOG YIELDS 17.0640 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	F 2	F 3	T 1	T 2
P 1	1.00				
F 2	0.00	0.00			
F 3	0.00	0.00	0.00		
T 1	0.00	0.00	0.00	1.00	
T 2	0.00	0.00	0.00	0.00	1.00


K7W
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 6
10 5
10 4
1000
100
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
52.5
OHM-M
25.8 M
9000
OHM-M
762. M
3.81
OHM-M
% ERROR: 32.2
CALIBRATION: 1
OFFSET: 152. M
RAMP: 200.0

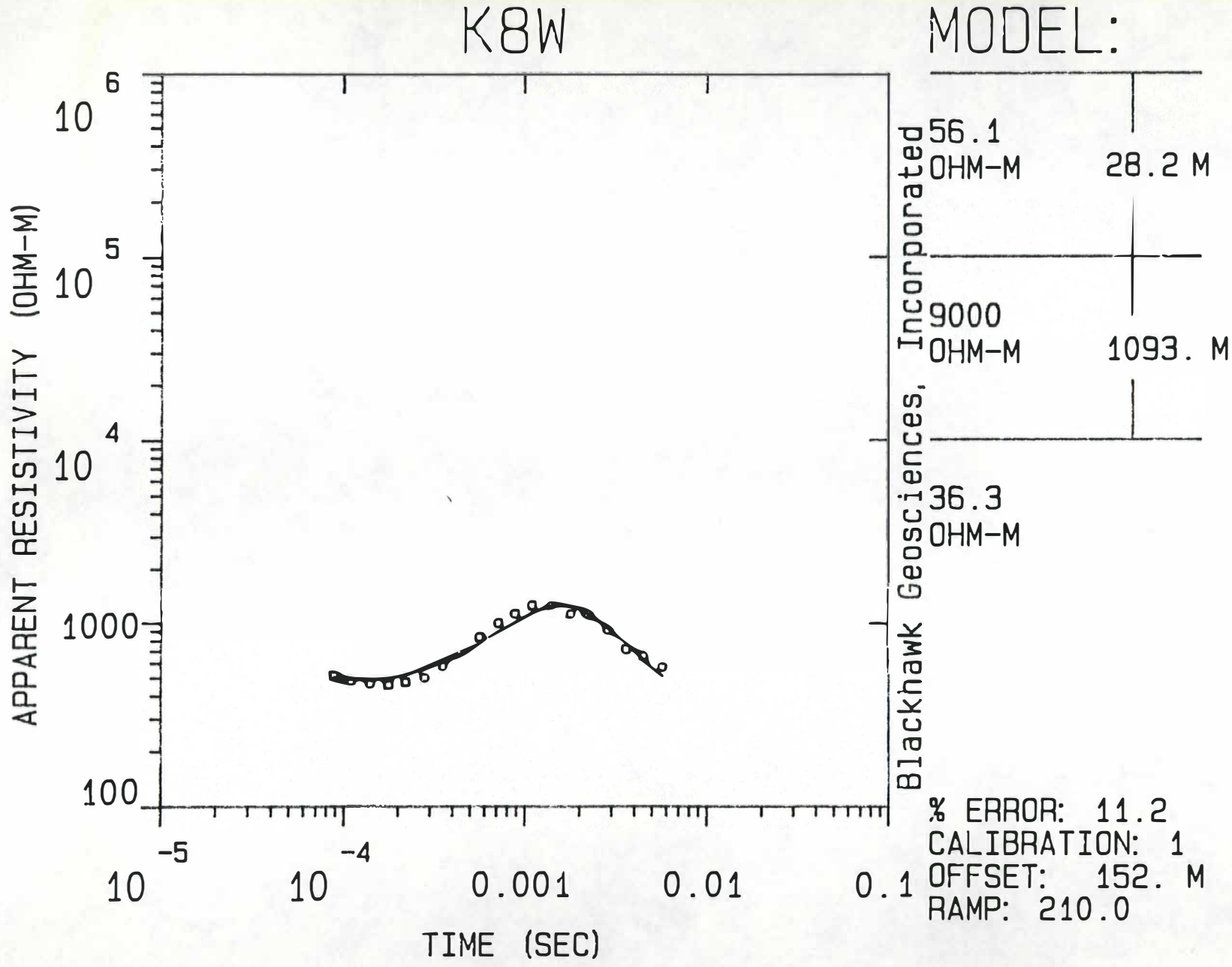
MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		512.1	1680.0		
52.50	25.8	486.3	1595.4	0.5	0.5
9000.00	762.3	-276.0	-905.6	0.1	0.6
3.81					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	5.09E+02	4.97E+02	2.354	
2	1.10E-04	4.89E+02	4.85E+02	0.868	
3	1.40E-04	4.84E+02	4.87E+02	-0.617	
4	1.77E-04	4.88E+02	5.04E+02	-3.078	
5	2.20E-04	5.13E+02	5.32E+02	-3.741	
6	2.80E-04	5.49E+02	5.81E+02	-5.502	
7	3.55E-04	6.46E+02	6.52E+02	-0.859	
8	4.43E-04	7.93E+02	7.43E+02	6.751	
9	5.64E-04	1.04E+03	8.76E+02	19.062	
10	7.13E-04	1.52E+03	1.04E+03	46.803	
11	8.81E-04	1.83E+03	1.18E+03	54.689	
12	1.10E-03	1.99E+03	1.27E+03	56.740	
13	1.41E-03	1.58E+03	1.20E+03	32.080	
14	1.80E-03	1.08E+03	1.00E+03	7.382	
15	2.22E-03	8.09E+02	8.09E+02	0.088	
16	2.85E-03	5.65E+02	6.14E+02	-7.974	
17	3.60E-03	4.39E+02	4.71E+02	-6.875	
18	4.49E-03	3.54E+02	3.67E+02	-3.560	
19	5.70E-03	2.92E+02	2.81E+02	3.714	
20	7.19E-03	2.44E+02	2.18E+02	12.085	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 20 DATA POINTS, RAMP: 200.0 MICROSEC, DATA: K7W
2404 100N 007W Z OPR XTL H 4 8+100
Ch.21 = 0.2 Ch.22 = 0.089 Ch.23 = 18 Ch.24 = 92
RMS LOG ERROR: 1.21E-01, ANTILOG YIELDS 32.1530 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *
CURRENT RESOLUTION MATRICES NOT AVAILABLE


K8W
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 6
10 5
10 4
1000
100
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
56.1
OHM-M
28.2 M
9000
OHM-M
1093. M
36.3
OHM-M
% ERROR: 11.2
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		574.5	1885.0		
56.12	28.2	546.4	1792.6	0.5	0.5
9000.00	1092.5	-546.1	-1791.8	0.1	0.6
36.32					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	5.20E+02	5.05E+02	3.019	
2	1.10E-04	4.85E+02	4.90E+02	-1.067	
3	1.40E-04	4.66E+02	4.88E+02	-4.669	
4	1.77E-04	4.61E+02	5.00E+02	-7.968	
5	2.20E-04	4.77E+02	5.23E+02	-8.756	
6	2.80E-04	5.06E+02	5.62E+02	-10.113	
7	3.55E-04	5.84E+02	6.17E+02	-5.468	
8	4.43E-04	6.89E+02	6.86E+02	0.421	
9	5.64E-04	8.43E+02	7.84E+02	7.575	
10	7.13E-04	1.01E+03	9.05E+02	11.379	
11	8.81E-04	1.14E+03	1.03E+03	9.856	
12	1.10E-03	1.27E+03	1.17E+03	8.385	
13	1.41E-03	1.25E+03	1.26E+03	-0.739	
14	1.80E-03	1.13E+03	1.24E+03	-8.704	
15	2.22E-03	1.13E+03	1.12E+03	0.858	
16	2.85E-03	9.22E+02	9.36E+02	-1.529	
17	3.60E-03	7.20E+02	7.70E+02	-6.438	
18	4.49E-03	6.68E+02	6.33E+02	5.523	
19	5.70E-03	5.78E+02	5.14E+02	12.359	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 19 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: K8W
2404 100N 008W Z OPR XTL H 4 8+100
Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 18 Ch.24 = 9
RMS LOG ERROR: 4.61E-02, ANTILOG YIELDS 11.1861 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.87				
F 2	0.00	0.00			
P 3	0.12	0.00	0.30		
T 1	-0.14	0.00	0.14	0.84	
T 2	0.00	0.00	-0.02	0.00	1.00
	P 1	F 2	P 3	T 1	T 2

Recd 5/23/90
1:20p

BLACKHAWK GEOSCIENCES, INC.
17301 WEST COLFAX AVE SUITE 170 GOLDEN, CO 80401
PHONE (303) 278-8700 FAX (303) 278-0789

BGI Fax No.: (303) 278-0789

FACSIMILE COVER LETTER

Date: 5/23/90

Please deliver the following pages to:

Name: Tom Nance

Company: Water Resources Eng.

City: Honolulu

Fax No.: (808) 538-7819

From: Mark Blakney Time sent: _____

There are 6 page(s) to this message including cover letter.

Sent by: Sms Telephone: (303) 278-8700

Additional Comments:

BLACKHAWK GEOSCIENCES, INC.
17301 WEST COLFAX AVE., SUITE 170 GOLDEN, CO 80401
PHONE (303) 278-8700 FAX (303) 278-0789

May 23, 1990

Tom Nance
Water Resources Engineering
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

Dear Tom:

We received the data from Ewa Marina from Rich this morning, and will begin working on the data.

To answer your questions concerning Kohala Ranch:

1) The inversion results are attached.

2) Your understanding of the inversion process is correct. We can fix parameters (such as the resistivity or thickness of a layer(s)) in order to optimize the determination of the other parameters. In fact, we do this quite often for the resistivity of the saline water lens (often fixed at 2.5 ohm-m). In the case of fixing the saline water at 2.5 ohm-m we do this because soundings taken at lower elevations often can derive this value fairly accurately. At higher elevations the soundings "look" towards a very conductive layer but cannot resolve its resistivity. By fixing it at 2.5 ohm-m, in these cases we reduce the relative error in depth to the conductive layer between the soundings.

3) With the TDEM method we are mainly sensitive to the conductivity of layers (the inverse of resistivity). For low values of conductivity (high resistivities) TDEM is not highly accurate. In the case of Figure 4-1, there are several reasons why we grouped a very large resistivity range into unweathered volcanics. These are:

   (1) Firstly, we cannot accurately determine high resistivities (e.g., > 500 ohm-m) in the inversion. For example, in Figure 1 the equivalence analysis for station 8 is shown. For this analysis all four-layer models which will fit the data to less than 3.7 percent RMS error are given. The error between the data and the model used in the report is 2.7%. Note how the two conductive layers are tightly constrained, and how

the two resistive layers show wide value ranges. In Figure 2 the same analysis has been performed for sounding 10 with the same conclusions;

(2) In nature slight changes in mineralogy can result in these wide variations at high values of resistivity for unweathered volcanics, and

(3) The TDEM data are interpreted using a one-dimensional layered resistivity section.

In the area suspected to be controlled by structures, etc., this 1-D assumption can be expected to be in error. And, therefore, caution must be exercised in interpreting the resistivities and thicknesses of units into geologic/hydrologic units. It is for this reason that more geoelectric cross-sections were not produced, and the interpretation was simplified to just grouping similar sounding results. External to the dike-controlled zone the 1-D interpretation is expected to be valid.

Sincerely yours,

BLACKHAWK GEOSCIENCES, INC.

Mark Blohm

Mark Blohm
Vice President

MB:sgf

Enclosure

Kohala Road TDEM soundings

Loop #	Elevation (meters)	Resistivity (ohm-m) ρ_1	ρ_2	ρ_3	ρ_4	Thickness (meters) h_1	h_2	h_3
1	579	96	1900	21	1775	51	316	340
2	439	497	5			407		
3	536	161	1967	1.8	1030	100	225	39
4	357	348	3.3			347		
5	616	164	1514	360		86	700	
6	472	138	4923	7.5		107	448	
7	509	236	18	182		288	449	
8	549	137	543	22	1672	82	154	271
9	433	4089	4.1			495		
10	564	186	4717	9.7		91	597	
11	378	1751	3.8			393		
12	585	137	336	79		35	691	
13	512	69	668	16	1049	40	165	125
14	465	283	4.8			427		
15	594	221	716	2.6	1688	127	213	62
16	576	220	>5000	7.6		109	557	
1W	253	1806	2.4			283		
2W	561	161	1050	32		74	584	
3W	530	198	1104	12		103	276	
4W	508	44	>5000	8.2		19.1	724	
* 5W	408	59	>5000	7.5		33	523	
* 6W	442	71	>5000	4.2		41	638	
* 7W	[illegible]512	53	>5000	3.8		26	762	
8W	575	56	>5000	36		28	1093	

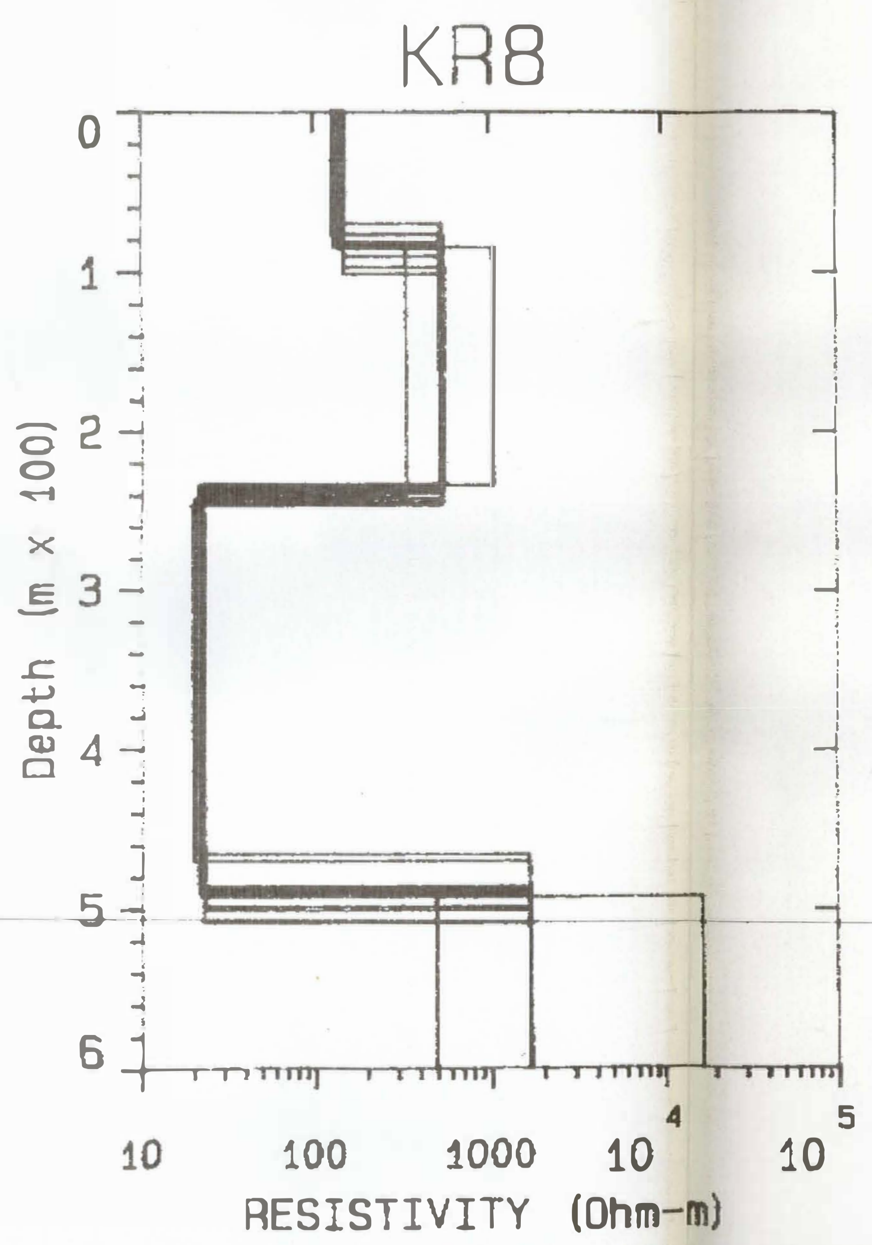

KR8
Depth (m x 100)
0
1
2
3
4
5
6
10
100
1000
10^4
10^5
RESISTIVITY (Ohm-m)

Figure 1

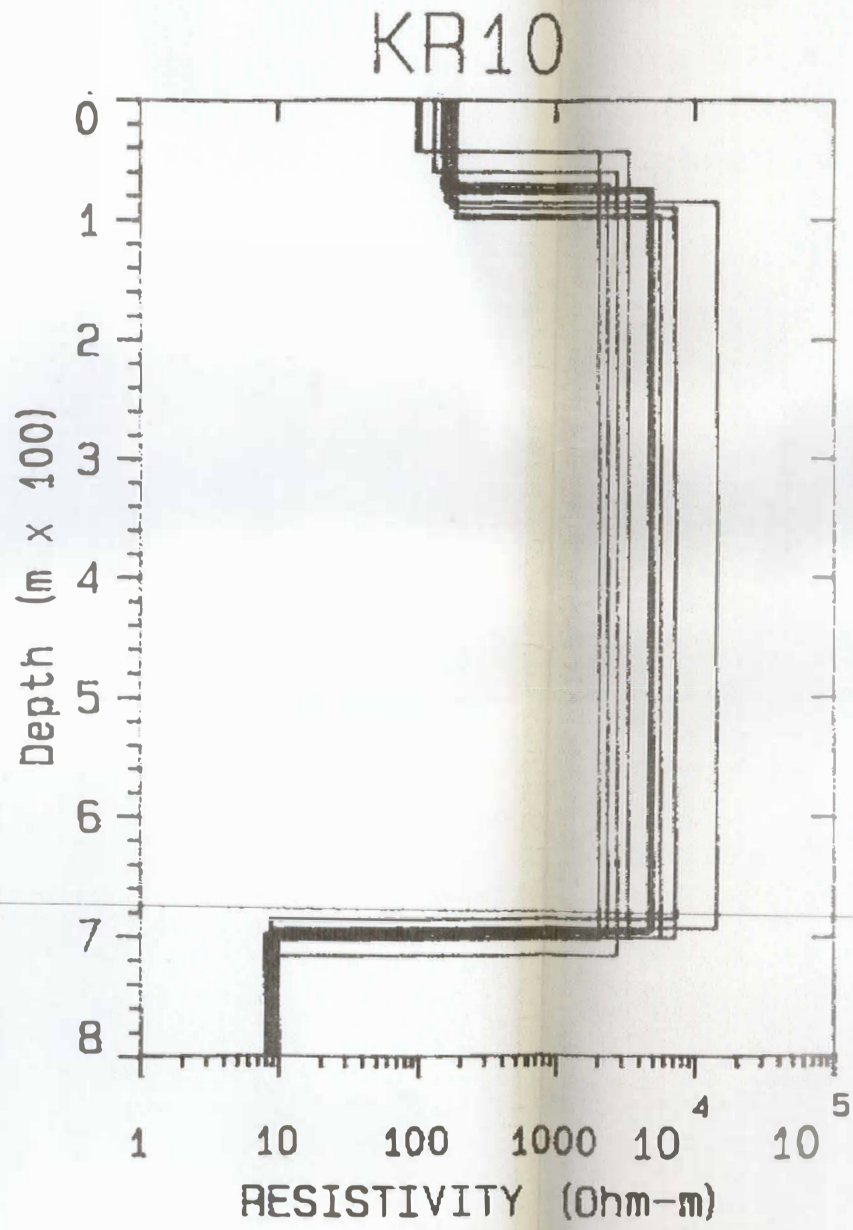


Figure 2